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BOTANY.—*Naming molds.*[1] CHARLES THOM, U. S. Bureau of Plant Industry.

I owe an acknowledgment to this Society for rehabilitation as a botanist. The office I am laying down tonight was my first elective position in a botanical society. I gave up a graduate assistantship under Atkinson at Cornell to turn dairyman in 1904, and that spelled heresy to some. In that period, I once joined the crowd outside the dining room door at the Annual Dinner for all Botanists. Some one presented me to one of the elect who looked at me rather sharply and said, "I don't remember any Thom as a botanist." I replied, "All right, call me a dairyman." He answered, "Oh, then I do know you!" I never found out who he was and have always wished I had made sure of his name. I should like to meet him right now.

When I left Cornell, I was assigned to the mycological phases of producing certain varieties of cheese already recognized as ripened by molds. My knowledge of molds was vague—I was superficially acquainted with a few Mucorini, and with one or two bright-colored Aspergilli; I was vaguely conscious of the general appearance of *Penicillium* and a few more of the common genera. I knew nothing at all of the technological task that I had acquired. Professor Atkinson had written the recommendation. He was frank about it; he assured the appointing power that he knew nothing about the project, neither did Thom, but that he had more work already than he could do, whereas Thom needed the job and had brains enough to fill it. No superlatives appeared (I have read the letter). I thanked him and reported for duty. You will readily understand that you are attending a kind of confessional or experience meeting where the confessor has spent some 35 years working with molds.

AN INDUSTRIAL MYCOLOGIST

Thus I became an industrial mycologist. I entered a field in which existing mycological literature was mostly useless and in which the be-

[1] Address of the retiring president of the Botanical Society of Washington, December 5, 1939. Received December 6, 1939.

ginner was left to feel his way among materials, factory processes, ripening conditions, and biochemical aims, all unknown to him and only vaguely known to his fellow workers who were dairymen, bacteriologists, and chemists. In some groups of botanists, my status as apostate was quickly evident. It was several years before I dared to face a botanical club, point to a distinguished ecologist in the room, and say, "I am an ecologist—just as much as my friend over there. The only difference is that I make the environment for my organism while he goes out and hunts for his." Academically, then, an industrial mycologist must be an experimental ecologist, and the user of ecological studies quickly learns that sound taxonomy is the essential background of ecology. Failure in the correctness of identification of the components of a plant formation in the field destroys the value of a report.

Nevertheless, as a beginner I was about in the fix of the rookie cavalryman who had never learned to ride but reported to the top-sergeant for training in horsemanship. That hard-boiled individual blurted out, "What? Never been on a horse before! Fine! Here is a horse that's never been ridden. You two may begin together."

Professor Atkinson was right—none of us had more than the vaguest idea of the task before us. When we went to the literature it paralleled closely a fellow-worker's characterization of the German literature about sauerkraut—"it was very extensive and not worth reading." Many cheese-ripening practices were described in countries of origin as "rule-of-thumb" procedures in which climatic or other factors supplied conditions often not defined even in the worker's mind, but actually necessary to success. However inadequate the available technological descriptions, the mycology was worse.

The molds present in the cheese industry were not difficult to isolate. Rigid preliminary survey did not leave many doubts as to which were significant. Verification involved technical problems that required years of experiment after the organisms were recognized. But when I started to find out what was already known about those molds I was in trouble.

My connection with the taxonomy of saprophytic hyphomycetes began at that point and has since led me in many directions. Some of this experience will be discussed here. If at any point I may seem to generalize, please remember that the title of this paper is just "Naming Molds"—not "Systematic Mycology"—however widely I might be tempted to apply my ideas.

Why give Latin names to those wretched little molds? I can not

answer, fundamentally, but I can make the trite observation that the human mind works that way. The objects one meets get named. If we are to understand each other then, we must be able to find out what the names used by our fellows mean. Thus far the reasoning is purely practical. For illustration, I once ran across a doctor of philosophy to whom the word butter meant apple butter; if you meant the stuff made from cow's milk, it was necessary to call it cow's butter to make him understand. And *he* took a job in the dairy! A name then, to be useful, must be an *accepted* designation for a very definite thing.

Mold information, whatever its value, is indexed under the Latin names of the molds themselves. And sometimes it is not very dependable. For illustration, one very up-to-date practical and modern journal in a perfectly proper technical article, published a new species name and description a few years ago for a mold so well known among culture men that nobody but the author and the editorial committee could possibly have failed to have met it before. Since it was new to that writer, he had burst into print with his one and only new species. Judged by the tables of contents, that journal puts no limitation upon the rotten practice of the "discovery" of an organism new to the "one-project worker" who thereupon prepares a description based upon his own lack of contact with the literature of the group and sends it forth to plague all subsequent students with the addition of another synonym, or, upon the equally obnoxious practice of collecting all the miscellaneous organisms occurring in connection with a special problem, labeling as new species all those that the sender does not know and sending them to a specialist to identify, always reserving the right to describe any organism that the specialist verifies as new. Such men, not being mycologists, escape the ban.

Let us get back to our cheese molds. The technological writers had copied Latin binomials from the books, with confidence, and added the describer's name in each case. *Penicillium glaucum* Link, *P. candidum* Link, *P. album* Preuss, and several other molds were listed without question marks. When I searched the cheese literature to find out how they had sorted out names and fungi, I was driven to believe they did it by Fisher's method—"at random."

Then I tried the mycological literature to see what the names had originally meant. I worked paper by paper back to Preuss (1851), then back to Link (1809). I went on back to Micheli (1729). Many believe that Micheli intended *Penicillia* by one of his figures, but it is too doubtful to trouble us now.

PENICILLIUM

There is no question about Link's generic idea of *Penicillium*, but there is no evidence as to which actual species he had when he described either *P. glaucum* or *P. candidum*. One man's guess is as good as another's—or as Link's (yes, or Brefeld's), for that matter. Link did not know his *P. glaucum* from any one of 100 green molds. Fifteen years later he put the whole green lot together and called them all *P. glaucum*, which was designated "the common green mold" in the fourth edition of the *Species plantarum* (1824). And the idea crops up yet, after more than 100 years!

Occasionally some one raised a doubt about a universally distributed green mold that grows upon and in everything, but the name was convenient; it satisfied the pedantic requirement for a Latin binomial to be applied to material that people were not willing to study. All local fungous floras report it. The popular writers accepted *P. glaucum* as *the green mold;* chemists took it up and tested "its" activity against every kind of substratum and reagent. With probably a hundred green species to pick from, *at random*, each was able to expand the range of biochemical activity reported. Naturally with different agents, contradictions crept in and raised controversy between individuals, but the popularity of *P. glaucum* was not abated—the mistake was always charged against the worker. *Penicillium glaucum* was sacred to the shades of Link and Brefeld.

A LIVE PROBLEM

I might go on and tell more of the story of nomenclature in *Penicillium* and *Aspergillus*, but all that has been published—and the indexes are good. Suppose I shift to a problem of nomenclature that is worrying a whole group of men today, and hang a general discussion around it.

These men work with human mycotic diseases; they have had experience in the great laboratories of the world; they have excellent instruments and refined technique; they have access to literature. From a series of rather horrible lesions on perhaps 60 patients living in widely separated places, they have isolated a number of strains of mold with certain characters in common and differences that offer a chance for individual judgment in classification. Between 1915 and 1939 these cultures have been assigned to about a dozen genera even though it is doubtful if there are really more than three species. These men disagree among themselves. I have been asked several times to express an opinion as to which is the proper name, but I hardly expect

any of them to accept my conclusion. The real question, however, is: Why is there so much disagreement when the descriptive data are not only readily established but in fact generally conceded?

A sketch of the nomenclatorial situation is necessary.

In 1915, a medical worker in Boston described a skin disease but without very definitely naming it. From the lesions studied he isolated a fungus that he decided belonged to an undescribed genus and species: *Phialophora verrucosa* Medlar.

In 1920, A. Pedroso and J. M. Gomes, working in São Paulo, isolated a similar organism from cases of Chromoblastomycosis. They accepted the same name, *P. verrucosa*, which has since been commonly cited as originated by Thaxter.

In 1921, Brumpt decided that the São Paulo fungus was not Medlar's organism but another species he called *Trichosporium pedrosoi* Brumpt. (Brumpt worked for a period in Brazil about that time.)

In 1922, Brumpt, having restudied the old literature, resurrected Bonorden's generic name, *Hormodendrum*, and changed the name to *H. pedrosoi*.

In 1922, Terra, Torres, da Fonseca, and Areo de Leao, in Rio de Janeiro, called the same organism *Acrotheca pedrosoi* (Brumpt) T. T. de F. and L.

In 1928, Ota distributed material under the name *Trichosporium pedrosianum* but later decided not to publish that species name.

In 1929, Langeron (Ota and Langeron collaborated about that time) again assigned Ota's mold to *Trichosporium pedrosoi* (Brumpt, 1921).

1930, da Fonseca and Areo de Leao again published the name *Acrotheca pedrosoi*.

In 1935, Dodge resurrected the name *Gomphinaria* from Preuss's 1851 paper and moved the species to that genus.

In 1936, Negroni proposed another new name, *Fonsecaea*, calling the fungus *F. pedrosoi* (Brumpt) Negroni.

In 1937, Moore and Almeida, after collecting and comparing strains, added three more generic names for the variations encountered, basing the usage upon the presence and combinations of spore-bearing structures. These names are *Botryloides*, *Hormodendroides*, and *Phialoconidiophora*.

In 1939, L. Briceno-Irragorry proposed another generic name, *Carrionia*, with *C. pedrosoi* (Brumpt) as its type species, arguing that this genus should include the organism of Chromoblastomycosis in South America.

CADOPHORA

In the field of forest pathology, Lagerberg, Lundberg, and Melin (1928) found species with the sterigmatic cups, which characterize the genus *Phialophora*, upon woody materials both in America and Sweden. They proposed the generic name *Cadophora* for those forms without recognizing their essential identity with *Phialophora*. More recently morphological and serological comparison of materials from human and forest sources in culture (Conant, Martin) supports the

identity of these genera; hence *Cadophora*, 1928, gives way to *Phialophora*, 1915. From the epidemiological point of view, however, Emmons (personal communication) finds grounds for belief that human infections find their inoculation in spores or mycelium from the plant-inhabiting fungi rather than from those upon fellow humans. As far as cases have been studied, man-to-man communication seems to have been excluded; hence he holds that we must search in the field among fungi growing upon vegetation for the strains responsible for cases of Chromoblastomycosis in man.

If further field study proves that these organisms are members of species regularly found upon decomposing plant remains, occasional infection of an individual human by spores or mycelia from such plant material does not warrant the establishment of either a genus or a species for that organism as a parasite. Many of these strains have grown well for me on sterilized plant material. This supports the view that search for them by culture from field samples offers a hope for solving some of these problems. Miscellaneous observation of great numbers of colonies of this dematiaceous series in connection with soil and food microbiology shows quite general growth at 37° to 38° C.—a condition usually regarded as a prerequisite to parasitism of warm-blooded animals.

HORMODENDRUM OR CLADOSPORIUM

The identification of these fungi from human lesions as congeneric at least with saprophytes or parasites of plant material turns our quest for nomenclature back to such older names as *Hormodendrum*. Bonorden (1851) distinguished his genus *Hormodendrum* from *Cladosporium* of Link (1816) by only one tangible character. Link had reported the spores of *Cladosporium* as 2-celled. Bonorden described the spores of his genus as 1-celled and transferred to it four species described by Corda as *Penicillia* but without personally seeing any of them, then added some "*Penicillia*" described by Fresenius, making a few disparaging remarks about Fresenius (1851). Two years later (1853) he clarified his ideas of *Hormodendrum* by actually describing one from fresh material (*H. atrum*). He left little doubt as to the general morphology of his mold.

Bonorden in his discussion clearly admitted that his material may, at least in part, have already borne the name *Cladosporium*. Among mycologists familiar both with specimens from the field and with the molds in culture, the 1-celled or 2-celled condition of the conidia is found utterly unreliable; hence the identity of *Hormodendrum* with *Cladosporium* has been quite generally conceded for 50 years at least.

As a consequence, application of the rules of nomenclature relegates *Hormodendrum* to synonymy.

Although Link's description of *Cladosporium* is no more definite than the other abbreviated Latin diagnoses of that time, the general nature of his material appears to have been recognized and the information handed down through continuous usage in the mycological laboratories and collections of his own and succeeding generations of workers. In this way his concept became more definite than *Dematium herbarum* of Persoon, which he believed to be the same material.

HISTORY OF CLADOSPORIUM

Before 1816, Link had assigned such forms as *Dematium herbarum* of Persoon to *Acladium* in 1809, after presumptively satisfying himself that they should be separated from the other species left in *Dematium*. Later he must have looked at them more carefully and concluded that they should be excluded from *Acladium* (branchless) and put into a genus whose name pointed to the distinctive character, branching (clados) spore chains. The code of nomenclature we use today for these groups of fungi begins to apply the priority rule with Fries's *Systema mycologicum* (1921–1932), rather than the previous publications of Link, Fries, or Persoon. Up to that time such arbitrary changes as we find in Link, Persoon, or even Fries merely furnish background for understanding the conditions under which the usages we have today were developing. *Cladosporium* is definitely recognized by Fries; hence it is valid.

CLADOSPORIUM OR SOME SEGREGATE

If, then, our reasoning is correct, these fungi isolated from Chromoblastomycosis must be assigned to *Cladosporium* unless adequate characters are available to separate some one or more of the series into one or more other genera. Without repeating details, I have already noted that the more careful workers agree that all the strains in question are closely related, at least (Emmons and Carrion, 1936).

In seeking lines for separating the series, describers have emphasized three kinds of spore production. All agree on the observation of some strains predominantly producing the *Cladosporium* or, to use their term, *Hormodendrum* type of spore chains: i.e., a more or less complex system of branching chains in which the newest cells or spores are constantly developing on the tips of the branches. They equally agree that other strains show progressive reduction of the branching system toward the ultimate simplicity of clusters of primary spores

aggregated rather densely about the clavate ends of the fertile hyphae (suggesting *Botrytis* to Moore and Almeida). Only an occasional individual cell in these groups develops a short series of buds of the *Cladosporium* type—some of them call this the *Acrotheca* type of spore formation. The fact of progressive reduction but never complete reduction, from the complex *Cladosporium* type of branching chains toward the *Acrotheca* type, leaves the homologies definite and readily recognizable.

PHIALOPHORA MEDLAR[2]

In contrast, the third type of fruiting structure is that described for *Phialophora*. Medlar figured hyphae with black or brown walls upon which directly or on short branches, singly or clustered, basal or sterigmatic cells develop. These cells termed by him phialids have firm brown to black walls and contract abruptly near the tip into spore-producing tubes, which then abruptly flare to form cups or cupules also with heavy brown walls. Colorless, thin-walled spores develop successively within the bases of the cups and tend to adhere about the tips in more or less sticky masses or spore balls. My statement is one of observation that they develop there but not how they are formed.

This structure is known to many mycologists from its presence in other series of imperfect fungi. In some species it is reported to be functional in connection with producing the ascosporic phase of life history. Outside of appearances in lesions, the life histories of the fungi of Chromoblastomycosis are entirely unknown; hence these cupules are for the present merely additional morphology, which can be used in diagnosis. Some species or strains show them regularly, some under limited conditions, while they are not known in other strains.

In culture, Miss Margaret Church and I studied the "*Cadophora*" type of structure from decaying plant materials at least 15 years ago. I have examined an occasional culture from pathogenic sources. Finally Dr. Emmons passed me 20 cultures from his collection, including transfers of strains received from Dr. Morris Moore as representing *Phialoconidiophora*, *Hormodendrum*, and *Botrytoides*. I have kept them in petri-dish and test-tube cultures for at least two months. It requires no imagination to find colony differences perhaps justifying separation into species, but essential similarities are equally ap-

[2] Not Thaxter! Even though Medlar acknowledged consulting Thaxter, he took entire responsibility for the naming and description of his species. Citation of the species as *P. verrucosa* Thaxter is common but unauthorized by any rule.

parent. I can find no reason for separating them widely. I can not agree that they should be placed in different genera.

Then how about selecting a generic name from the available dozen and putting them into it? The objection is raised that particular names are based upon the presence of particular types of spore formation, while in the cultures these do not always satisfactorily correspond with any one of the descriptions. If the group of strains from human sources appears to be too homogeneous to place in separate genera, as I think, the priority rule settles the question without further debate. *Phialophora verrucosa* of Medlar was certainly one of the series and was described first. A generic name once established loses its etymological limitation and becomes the designation of an aggregate rather than a unit or single species. Medlar's organism would be the type species. His generic description would need emendation, but that is readily furnished. Such a separation appears to be justified by the preponderance of observations to date and should be broadly enough established to include some at least of the "*Cadophora*" series described by Lundberg, Lagerberg and Melin, and others. The student of this "*Cadophora*" series upon vegetation and in culture is sufficiently impressed with its contrast in colony and spore producing characters in comparison with the "*herbarum*" lot in *Cladosporium* to be unwilling to assign them to *Cladosporium;* hence he would choose the alternative of broadening the generic diagnosis of *Phialophora* to cover the series showing these common characters until further life history studies determine real relationships elsewhere, if any. In other words, as I see it, the well-established saprophytic series "*Cadophora*" determines the placement of the vagrant members of that series which are found here and there throughout the Western Hemisphere as the cause of Chromoblastomycosis in individual humans, each time apparently *de novo*.

EPIDEMIOLOGICAL ARGUMENT

Epidemiological isolation of these cases clearly disposes of any necessity to recognize the parasitization of the individual human as justifying the separation of the causal organism, as isolated from the patient, generically or specifically from the inoculum that produced the lesion. Each organism isolated from such a lesion is to be considered merely a stray member of a species abundant in another environment. Such an occurrence is not essentially different from growth in a petri dish, which frequently diverges in superficial characters from the colony as seen in nature. In this series, then, the imag-

inary wall between fungi growing on vegetation and as fungous parasites of man has broken down. As in many other biological situations, the idea of specificity which limited organisms to particular and narrow biochemical roles proves to be false.

BACK TO BIBLIOGRAPHIC HISTORY

Having illustrated my topic by proposing an answer to a specific question, I must now go back and discuss the broad aspects of my task—naming molds. The causes of such controversies as I have just described lie back in the history of mycology covering the past 200 years. The original mycologists were essentially microscopists—laboratory examiners of material, who applied rapidly evolving microscopic methods to the description of specimens collected by themselves or others. I am sorry to express the conviction that there are many today who go little farther in their examination than Link or Persoon even though with better microscopes and more adequate literature they can not avoid seeing more.

THE FIRST 100 YEARS

If we follow back the descriptions of molds to Micheli (1729) we find that he separated the half dozen or so molds that he called *Aspergillus* (rough headed) as yellow, white, green, black, etc. There were 2 or 3 Asperigilli, probably a *Penicillium* or two, or some Mucors among them. Color seemed to him all he needed for separation. By the beginning of the nineteenth century, Persoon and Link, with a larger series of molds to separate, had raised the requirement to 3 or 4 lines of Latin. Their figures clearly indicate that their microscopes were low in magnification, but their descriptions and figures seemed adequate to men who had only a few forms to separate but did not help the next fellow who had only a few, but a different few. Details of structure and cell arrangement were not seen and were not thought necessary.

Corda (1830–1840) went a bit farther—he had a better microscope and figured individual cells, but their origin and relationship were not even considered among his recorded data. Corda could draw nice pictures—the only trouble with them has been that no one else has ever been able to find anything like his pictures of some of these evanescent molds, however valuable his drawings may be in other groups.

By 1850 Montagne concluded that most of these old descriptions of delicate fungi were entirely uninterpretable.

These men were busy naturalists—explorers of the new domain opened up by the compound microscope. Their colleagues were clam-

oring for information. Collectors in distant lands piled the tables of Linnaeus, Persoon, Link, Fries, Berkeley, Cooke, and the rest with unknown specimens. What wonder that each described in hasty terms everything that came or matched it briefly against his predecessor's briefer description, then identified or separated it and passed it into his collection. Unfortunately, most of these specimens of the more delicate fungi kept even under the most careful management quickly dried up, separated into powder, and disappeared. Verification from type specimens is thus impossible.

CULTURE ENTERS THE CONTROVERSY

Culture did not appear in the mycological literature until the time of deBary, about the 1850's, and was not used seriously for descriptive purposes before van Tieghem in the 1860's and Brefeld in the 1870's.

Brefeld did a prodigious amount of work, but he also was an artist as well as a mycologist, so that one who studies his figures with a hand lens finds that he established an interpretation in his mind, then covered the paper with diagrammatic drawings that often tally with the idea more closely than with the material under his microscope. I am not undervaluing Brefeld as a pioneer. He did much, but as to details he left much undone, and we must not hesitate to correct mistakes incident to method and equipment.

There was a parallel development of mold culture in France in the laboratories of Raulin, van Tieghem, Bainier, Gueguen, and others. Both groups of pioneers tended to assume that every form found was new, that the number of species was small; hence fragmentary descriptions run from one line to ten in length, without enough comparative work among groups of congeneric species to develop the discrimination between fundamental and ephemeral characters.

EXPANDING THE DIAGNOSIS

Technological mycology, as far as molds are concerned, i.e., the controlled utilization of particular and definitely known molds in accomplishing biochemical processes, began to appear in the literature in the 1860's. By the 1890's, a number of such processes were fairly well recognized. Sopp and Wehmer, both students of Brefeld, made extensive studies of Penicillia and Aspergilli in connection with industrial problems. Again, the items included in an adequate description were greatly increased.

In this period (1860–1890) culture as a basis of description was deemed satisfactory if a colony was obtained by any procedure. Data

from such a colony were regarded as information accessory to the study and descrip' n of natural masses presumed to be typical but were not included n diagnosis of the species. By 1890 some efforts were made to insure the purity of the colony. In the succeeding decade (1890 to 1900) species diagnoses based on colonies grown on laboratory media began to appear, limited to saprophytic molds. The substratum upon which the colony had been originally found continued to hold the key position as "habitat," which might mean much or nothing, according to the care with which the natural situation was studied and described. Many still consider designation of the place where the original specimen was obtained to be the only proper habitat to be cited. Unfortunately the habitat-substratum very commonly means only that the first gross inoculum was found there, not that the organism isolated was specifically active upon that substratum.

DEMANDS OF "APPLIED MYCOLOGY"

Thus far the methods and descriptive practices applicable to the molds used in industrial work were not differentiated from those of general mycology. The exacting demand for molds with specific adaptability to important biochemical uses began to be felt in the 1890's. Wehmer took out patents about 1893 for the manufacture of citric acid, using *Citromyces* as the fermenting agent. By 1905, he admitted that he thought at first that there were only two species, whereas he had now found that there were not less than six and he did not know which was which. Now we know there are many more.

Industrial use calls for exact information as to the biochemical possibilities of each mold. Culture media and conditions must be described with such definiteness that experimental work can be repeated and checked by analysis. Species must be described in terms sharp enough to insure identification.

Green Aspergilli are not adequately covered by the name *Aspergillus glaucus* nor all green Penicillia by *P. glaucum*. Means must be found to make species more tangible than rough aggregates held together by one or a few vague adjectives. The number of genera and species have increased beyond the wildest dreams of the early mycologists. In the effort to produce descriptions that will insure identification, species diagnoses have become progressively detailed and complicated. An extreme case may be cited: Strains of a great group were collected for many years. In working them over the monographer first developed punctilious notes as to the culture reactions of his whole series upon about half a dozen selected media. While making

these notes, he preserved colonies of each species in alcohol. After the biochemical record was completed, a mount of each species was made with extreme care and a plate of drawings representing that species was prepared. When all the plates were finished, he prepared his Latin diagnoses by describing the structures and variations depicted in his plates! Then the accumulated mass of data was sorted out to species, pieced together, and published. This is one illustration in connection with a monograph, purely academic in character. In practical fact, there are many unrecognizable species among those described in detail within the last few years, and by all of us! WHY?

UNINTERPRETABLE DESCRIPTIONS

There are several reasons for failing to identify species from descriptions. There is little agreement as to just what characters are fundamental to genera and to species, and which are incidental variations representing direct response to environment. Great stress has has been put upon numbers and measurements of parts or details of branching systems. Large numbers of spores have been measured to the fraction of the micron, then the totals averaged or statistically analyzed to the fraction of a micron. As a result, emphasis upon unimportant details has often claimed the users' attention while the fundamental information escaped.

ESSENTIALS OF DIAGNOSIS

A safe description requires the exact identification of the culture substratum, of the biochemical effects of the culture upon that substratum, and correspondingly a series of observations of the organism itself upon that substratum.

Purity of culture is essential. The presence of bacteria, *Actinomycetes*, or other molds often alters colony characters. Different contaminants produce different alterations; hence entire elimination of other organisms is essential. Unfortunately, there are quite well-known laboratories from which cultures consistently show mites, as well as molds or bacteria. One is compelled to believe that some workers have never yet seen mites, recognized their ravages in culture, or distinguished the characteristic smell that usually betrays their presence.

More important yet, actual relations and sequences between cells are fundamental. New cells may be formed by fission: The older cell is cut into equal halves; or, they may bud out at one of a dozen places

and in one of a dozen ways. Chains of spores may arise by budding so that the newest cells are always farthest from the basal cell or sporophore. Unbranched chains commonly arise from a basal cell—always showing the distal cell as the oldest while the newest cell is attached directly to the basal or sterigmatic cell. Again, this observation is fundamental.

A description of a ripe spore mass as a mass, or, pulled to pieces and the pieces described as found, may miss completely the significant facts. Whole series of descriptions that disregard cell succession in spore formation are simply uninterpretable, except in species in which satisfactory material was preserved or which have been found identifiable from some other line of observation.

Finally, details of cell wall structure (as Jeffrey said about paleobotanical specimens) may furnish as many real clews to relationship as the orthodox observation of sporogenous masses. Whole series of Aspergilli and Penicillia show such consistent markings of the stalk wall that examination of the sporophore wall with oil immersion objectives furnishes the most useful, most general, in fact, most easily determined series character.

But the nomenclatorial sins are not all chargeable to describers. The most striking lack among users of descriptive literature is in the appreciation of the cell relations involved in whatever structures they find. They fail to give proper consideration to cell contents, cell walls, their structure, color, and markings, to cell-succession in the formation of the sporogenous tissue seen under the microscope, and to the methods of aggregation of spores shown by heads, chains, or discharging mechanism. In other words, they fail to understand that identification of a mold is not accomplished by a superficial examination with a hand lens or with the low magnifications of the microscope. Exacting observation of the detail indicated in descriptive keys is ordinarily guided by those same keys. Failure to follow out definite instructions is hardly justifiable.

In the more complicated groups, it is not just matching a culture at a glance against a list of names, but the integration of all that one can learn by painstaking examination against the literature and investigations of perhaps 100 years. Into that investigation must go a first-hand knowledge of the life history of not one or two species but whole groups of species; it must include many years of observation in the field, controlled development in the culture room, and diligent reading in the library.

The need for care in establishing one's right to use generic and specific names can not be brushed away with a wave of the hand.

I sat beside a well-known worker not long ago and heard him tell an inquirer, "Why bother about the name—select one of them, go ahead and study your organism, and let future systematists decide where your organism belongs!" That dictum may suffice for some folks! But it creates chaos when the industrial or technological scientist makes the wrong selection and puts a series of industrial or biochemical papers about genus "X" and species "Y" into the literature when he actually worked with genus "A" and species "B." Indexed that way, an error is often cited many times as a fact by workers who have no means at hand to protect themselves. This is no hypothetical dilemma. I can name instances. Men regularly ask me for cultures based on such papers. Sometimes I can guess what they want; sometimes I have no idea why they make the request. Again I am sure they selected names at random.

In direct controversion of the dictum above, I believe it safe to say that a critical cultural and microscopical study of saprophytic molds will in the vast majority of cases throw together into homogeneous groups the things that eventually prove to belong together even though exact relations among them can not always be predicted from the hyphomycete stage.

To the industrial mycologist who is confronted by a mold isolated from where you please—important or merely questionable—the problem of what to call it is not theoretical, but practical. He should be able to examine the thing before him and reach some diagnostic characters that will lead to the correct literature of the species. In other words, however unimportant naming may be, as an end in itself, the descriptive and taxonomic problem must be solved before he can reach what his predecessors and perhaps his colleagues have written about the particular thing on the table.

If you are to do technical work with a particular mold, the fundamental dictum is: Know your organism by name and relationship, know it morphologically and physiologically, macroscopically and microscopically—know it so well that if anything goes wrong, you will detect the abnormality and correct it or make an adequate record. That applies whether you are a mycologist, a pathologist, a chemist, a physiologist, or any other brand of specialist; the man who fails to know his organism thoroughly is helpless before contamination, losses, or replacements, which often destroy the value of the results.

SUMMARY

I have tried to picture to you some of the problems of the "applied mycologist" who works with the so-called "common molds." As factors in human affairs, they spoil man's food, mildew his clothes, pollute his storerooms, and even attack his body. He gets some return by eating a few of them and using others in controlled fermentations of many kinds. He can not escape from them—he must live with them. The alternative, then, is to know them—individually, that he may use or combat the single species; as groups, that he may so compare and systematize his information that each item in it may contribute to arranged and ordered systems of knowledge. In a recent memorial to a great museum specialist, his services to mankind are listed as "(1) Scientific research, (2) Nomenclatural," etc. One makes bold to say that there is fully as much reasoning exhibited in comparing, reconstructing, and classifying a fossil as in digging it out of a hillside. The one dictum that must not be forgotten is that no single item has permanent value unless it represents the closest approximation to truth that can be reached by using all the means available. Any work, to be worth while, must be a rigorous search for truth. No bypath can be permitted to lure the worker aside for fancied results. If rigorous good faith in method, in performance and in interpretation are maintained, usefulness from the results can not possibly detract from the purity of the science. It is not the "pot of gold" that pollutes; it is the method of getting it. It is true in applied mycology as everywhere else that "He that entereth not by the door into the sheepfold, but climbeth up some other way, the same is a thief and a robber." If the solution of problems in human service makes our work applied science, then let us glory in the name.

CHEMISTRY.—*Anselme Payen, distinguished French chemist and pioneer investigator of the chemistry of lignin.*[1] MAX PHILLIPS, U. S. Bureau of Agricultural Chemistry and Engineering.

In these days when there is so much research activity on the chemistry and utilization of lignin and cellulose, it is fitting that we pause and pay our respects to the memory of a man who was a pioneer investigator of the chemistry of these two substances and who is now virtually forgotten. This man, Anselme Payen by name, published the results of his investigations on lignin and cellulose about 100 years ago. Although the percentage elementary composition of wood had previously been determined by Gay-Lussac and Thenard, Payen was the first one to attempt a separation of wood into its component parts. He treated wood with nitric acid and obtained a fibrous substance, which was relatively resistant to this reagent. This substance Payen called "cellulose," a term that he coined and introduced into chemical literature (Compt. Rend. Acad. Sci. Paris 8:51. 1839). He showed that cellulose had the same percentage composition as starch, and was apparently isomeric with it. He found that irrespective of its origin, cellulose had the same chemical composition, which could be represented by the formula $C_6H_{10}O_5$ and was apparently the identical substance in all plants. Payen also found that in isolating the cellulose he had to remove a substance or a group of substances, which had a higher percentage of carbon than cellulose. These substances Payen called "incrusting materials" (*"les matieres encrustantes"*), and he considered that the cellulose was mechanically incrusted or impregnated by them. These incrusting materials were later (1857) designated by Schulze as lignin, a term previously used by the botanist and plant physiologist de Candolle. The "incrustation hypothesis" of Payen was in the main supported by Schulze, although other investigators, among them Erdmann, opposed Payen's views. It is of interest, however, to point out that Payen's "incrustation hypothesis" has in more recent years been vigorously supported by Wislicenus and by Freudenberg.

Anselme Payen was born in Paris, France, on January 6, 1795. He was the son of Jean Baptiste Pierre Payen and Marie Françoise Jeanson de Courtenay. The elder Payen was educated at the Collége de Navarre in Paris, where he distinguished himself especially in philosophy and in the sciences. Through the insistence of his parents, how-

[1] Read before the Division of History of Chemistry at the 98th meeting of the American Chemical Society held in Boston, Mass., September 11 to 15, 1939. Received December 11, 1939.

ever, he studied law and was for a time assistant to the procurator of the King for the city of Paris. This legal work, however, did not prove to his liking and in 1792 he established a factory at Grenelle, a suburb of Paris, for the production of various chemicals, chiefly sal ammoniac. This enterprise proved to be quite successful, and we soon find him engaged in the production of other chemical substances, such as sulphuric acid, hydrochloric acid, borax, refined sulphur, soda, and gelatin. He also established at Vaugirard a factory for the production of sugar from sugar beets. This was then a new industry in France, and during the continental blockade of the Napoleonic wars the cultivation of sugar beets and the extraction and refining of sugar therefrom were greatly encouraged by the French Government.

Anselme Payen received his early education from his father, who was a strict disciplinarian and very early inculcated in his son the habit of systematic study, a characteristic he retained for the rest of his life. However, in order to get a thorough grounding in the sciences his father sent him to the École Polytechnique in Paris where he studied chemistry under Vauqeulin, physics under Fourcroy, and mathematics under Trémery.

When young Payen was hardly 20 years of age his father placed him in charge of a plant for the refining of borax. This was then a relatively new industry in France for the Dutch virtually had a monopoly of the production of refined borax in Europe. The crude borax containing material was imported by the Dutch from the Orient and then refined by them. Young Payen conceived the idea of preparing borax synthetically from soda and boric acid, which was then obtained almost entirely from the hot springs and lakes of Tuscany. Payen's efforts were crowned with success, and in 1820 he placed on the market synthetic borax at one-third of the then prevailing price and thus succeeded in establishing a new industry in France.

In 1820 Payen's father died, and at the age of 25 years the young man had to assume full responsibility for the management of several factories established by his father, including the factory for the production of sugar from beets. For the clarification of the sugar solutions vegetable charcoal, principally wood charcoal, was employed. This peculiar property of wood charcoal was first brought to the attention of chemists in 1785 by an apothecary by the name of Lowitz of St. Petersburg, Russia, although according to E. O. von Lippmann the decolorizing property of wood charcoal was known as early as the fifteenth century to some of the German alum and saltpeter producers. However, this observation was apparently entirely forgotten. As al-

ready mentioned, among the chemicals made by Payen in his factory at Grenelle was sal ammoniac. This was prepared from the complex mixture of volatile substances obtained by the destructive distillation of bones and other products of animal origin. In the retort there remained a charred mass known as animal charcoal or bone char, which was then largely a useless by-product. Although Figuier of Montpellier in 1811 called attention to the decolorizing property of animal charcoal no application was made of this discovery until Payen got interested in this problem. Payen was motivated in this study by the double objective of improving the process of sugar refining, and of utilizing the animal charcoal. In a paper published in 1822, entitled "Theory of the Action of Animal Charcoal and Its Application to the Refining of Sugar," Payen gave results of a thorough study of the decolorizing properties of animal charcoal and pointed out that it owes its activity to the peculiar shape and state of aggregation of the carbon in this material. He also showed that it had the capacity of removing certain salts from solution and thus facilitated the crystallization of the sugar. He also developed an apparatus, called a "decolorimeter," for the determination of the decolorizing ability of various lots of animal charcoal. This may be considered the first important scientific paper published by Payen.

The credit for first using animal charcoal industrially for the refining of sugar clearly belongs to Payen. It was as a result of his zeal and industry that the popular prejudice against the application of animal charcoal to the refining of substances used for human consumption such as sirup and sugar was overcome. In addition to thus improving the process of sugar refining, Payen's work resulted in establishing an important new industry, namely, that of animal charcoal production. We thus see that a product which had heretofore been entirely useless became the basis of an important new industry. Few sugar technologists are today aware of the fact that when they decolorize their sugar solutions by means of animal charcoal they are making use of a method of sugar refining introduced more than a century ago by the French chemist Payen, now all but forgotten.

Because of his work on sugar beets, Payen very early in his life became interested in agricultural chemistry, and in the application of science in general to the improvement of agricultural practices, an interest he retained throughout his long and useful life. In these days when we hear so much about the industrial utilization of agricultural products, it may be of interest to point out that Payen more than 100 years ago not only advocated this very thing, but also made impor-

tant contributions toward its realization. In a book he published in 1826 together with Chevalier, entitled "Traité de la Pomme de Terre" (Treatise on the Potato), he described in considerable detail not only the preparation of various foods and feeding stuffs for human and animal consumption, including the production of sugar and sirup, but also the methods for the preparation of starch and alcohol from potatoes. Part of the results contained in this book were published in the Proceedings of the Central Agricultural Society of France in the year 1823 and in recognition of this work Payen was given a gold medal by that society.

In the early part of the nineteenth century the need arose in France for the development of more economical methods of disposal of the carcasses of domestic animals that died of accident or of diseases of an epidemic character. Accordingly, in 1825 the Central Agricultural Society of France offered a first prize of 1000 francs for the most practical and economical method for the utilization of the carcasses of these animals. In 1830 the first prize was awarded to Payen for his 132-page memoir, which was published in the proceedings of the society for that year. There is a great deal of analytical data in this paper, which in many cases were obtained by methods devised by Payen. The method developed by him for the determination of nitrogen consisted in heating the sample to red heat and collecting the gaseous products in dilute sulphuric acid. While this did not, of course, give him all the nitrogen in the sample in the form of ammonia, it is nevertheless of interest from the historical standpoint as it was the forerunner of the Will and Varrentrapp method, where it is recalled the sample is heated with soda-lime and the ammonia collected. This was later superseded by the now well-known Kjeldahl method.

The methods that Payen described for the utilization in industry and in agriculture of various products of animal origin have proved to be practical, and many of the processes now in use for the utilization of the by-products of the meat-packing industry can be traced to those described by Payen in his paper published more than 100 years ago.

In 1835, at the age of 40, Payen gave up all active participation in the various manufacturing enterprises that he was interested in and accepted the position of professor of industrial and agricultural chemistry at the École Centrale des Arts et Manufactures in order that he might devote all his time to teaching and scientific research. In 1839 in addition to his duties at the École Centrale he also accepted the professorship of applied chemistry at the Conservatoire des Arts et

Métiers. These two positions he held until the time of his death.

The next 36 years of Payen's life were undoubtedly the most fruitful of his entire career, judged from the many contributions of a fundamental character he made to chemistry. He published about 200 scientific papers in various scientific journals such as the Comptes Rendus, Bulletin de la Société d'Encouragement pour l'Industrie National, Annales du Conservatoire des Arts et Métiers, Annals de Chimie et de Physique, Annales d'Histoire Naturelle, Bulletin de la Société Chimique, Journal de Chimie et Médecine, Mémoires de la Société Centrale d'Agriculture de France, Annals des Mines, and others. These papers covered a wide field of investigation and included such subjects as starch, dextrin, sugar, lignin, cellulose, bitumen, and various phases of agricultural chemistry including studies on plant and animal nutrition, the latter studies being conducted in cooperation with the famous agricultural chemist Boussingault. He also published papers in the field of inorganic chemistry. It was in connection with his studies on starch that Payen together with Persoz discovered the enzyme diastase. The paper on starch that he published in 1836 is remarkable for its clearness and precision. He showed that starches obtained from different sources differed as to size, shape, and state of aggregation, but that they all had the same chemical composition.

Payen had a practical turn of mind, and in the midst of his work on the purely scientific phases of chemistry he was always interested in the application of chemistry to industry, agriculture, hygiene, and medicine.

Payen was a prolific writer of books on industrial, agricultural, and food chemistry, and many of his books became standard works of reference and were translated into English and into several other European languages. Special mention should be made in this connection of his "Traité de Chimie Industrielle," in which Payen describes in great detail the various processes then used in chemical industry. Even the superficial reader of this book can see at once that its author was not a mere compiler, but rather one who has actually had many years of practical experience in the operation of the several processes described by him. In fact many of the processes there described were developed and improved by Payen. From the titles of the various books published by Payen one may get some idea of his extensive knowledge and interests.

The following is a list of his more important books (for a complete list of Payen's books the reader is referred to H. C. Bolton's "A Select Bibliography of Chemistry," Washington, 1893):

(1) Traité de la pomme de terre; sa culture, ses divers emplois dans les préparations alimentaires, les arts économiques, la fabrication du sirop, de l'eau-de-vie, de la potasse, etc. Paris, 1826. (Published with Chevalier.)
(2) Traité de la fabrication et du raffinage des sucres. Paris, 1832.
(3) Des engrais. Théorie actuelle de leur action sur les plantes principaux, moyens d'en obtenir le plus d'effet utile. Paris, 1839.
(4) Mémoire sur l'amidon, la dextrine et la diastase consideres sous les points de vue anatomique, chimique, et physiologique. Paris, 18—.
(5) Précis de chimie industrielle à l'usage des écoles préparatoires, aux professions industrielles, des fabricants et des agriculteurs. Paris, 1849.
(6) Précis d'agriculture théorique et pratique a l'usage des écoles d'agriculture, des propriétaires et des fermiers. Paris, 1851. (Published with A. Richard.)
(7) Traité de la distillation des betteraves. Paris, 1854.
(8) Traité complet de la distillation des principales substances qui peuvent fournir de l'alcool; vins, grains, betteraves, fecule, tiges, fruits, racines, tubercules, bulbes, etc. Paris, 1857.
(9) Précis théorique et pratique des substances alimentaires et des moyens de les améliorer, de les conserver et d'en reconnaitre les alterations, 4th ed., Paris, 1865.

According to Ostwald most great men can be divided into two classes. Those who in their youth, that is to say between 20 and 35 years of age, do their most outstanding work belong to the romantic type. Those who belong to the classical type are men who do outstanding work during their entire life. Payen clearly belonged to the latter class.

Payen was a member of many scientific societies. He was elected a member of the Central Agricultural Society of France (La Société Centrale d'Agriculture de France) in 1833 and was its permanent secretary for 26 years. He was elected a member of the French Academy of Sciences in 1842. Among the other societies to which he belonged may be mentioned l'Academie de Médecine, Société d'Encouragement pour l'Industrie Nationale, Société d'Horticulture de la Seine, and of the Council of Hygiene and Public Health.

Payen served the French Government in diverse capacities, particularly as a member of various governmental commissions. He was made a Knight of the Legion of Honor by Charles X in 1828. Louis Philippe made him an officer of the Legion of Honor in 1847, and in 1863 Napoleon III elevated him to the rank of commander.

One of the characteristics of Payen was his intense patriotism, and for 40 years he served as commander of the battalion of National Guard of the town of Grenelle, where he made his home.

In 1821 Payen married Zelie Charlotte Mélanie Thomas, which proved to be a very happy union. There were five children in the family, four of which, however, died in childhood and only one child, a daughter, survived him.

Payen's last days were greatly saddened by the disasters that France suffered as a result of the Franco-Prussian War. In spite of his advanced age he refused to leave the city of Paris on the approach of the Prussian army and displayed a great zeal in the study of all problems relating to the feeding of the besieged and famished city. On May 9, 1871, while attending one of the sessions of the Academy of Medicine he became ill and died three days later (May 12). Few of his friends and comrades were able to pay their last respects to this distinguished savant, for those were the days preceding the establishment of the Paris Commune and civil war raged on the streets of Paris. He was buried in the cemetery at Grenelle.

The biographic material contained in this paper was obtained from the following sources:

(1) Amer. Journ. Pharm. (ser. 4) **1**: 432. 1871. (Anon. obituary notice.)

(2) Éloge biographique de M. Anselme Payen, by J. A. Barral, in Mémoires Publies par la Société Centrale d'Agriculture de France, pp. 67–87. 1873.

(3) Éloge de M. Payen, by Aimé Girard, in Annales du Conservatoire Imperial des Arts et Métiers **9**: 317–331. 1873.

A complete list of the scientific papers published by Payen can be found in the Catalogue of Scientific Papers, compiled by the Royal Society of London.

BOTANY.—*Eight new species of* Pariana. JASON R. SWALLEN, U. S. Bureau of Plant Industry.[1]

Pariana is an anomalous genus of grasses that inhabits tropical forests and forest borders from Panama to Brazil and Peru. Because of the paucity of material in herbaria, the species have been considered as rare. The author, however, in 1933–34 observed these grasses growing rather commonly in northern Brazil, in places even completely covering the ground over rather large areas. The inflorescences are frequently entirely hidden by the foliage, which may account for the earlier collectors overlooking them. Tutin[2] recently revised the genus recognizing 23 species. Since then, one has been described from Ecuador by Pilger.[3] The eight species herein described bring the total number to 32.

Pariana nervata Swallen, sp. nov.

Perennis; culmi uniformes e rhizomatibus crassis erecti, 90–130 cm alti; vaginae inferiores internodiis longiores vel breviores laminis obsoletis, superiores internodiis multo longiores foliosae, auriculatae, sparse fimbriat-

[1] Received October 26, 1939.

[2] *Revision of the genus* Pariana. Journ. Linn. Soc. Bot. **50**: 337–362. 1936.

[3] Notizbl. Bot. Gart. Berlin **14**: 323. 1939.

ae, glabrae vel sparse pilosae; ligula 3 mm longa, truncata; laminae 15–26 cm longae, 4–6 cm latae, acuminatae, infra scabrae; inflorescentia pendula, 20 cm longa, 1.3 cm lata; spiculae masculae 6.5–8 mm longae, pedicellis occultis, 3 mm longis minute pubescentibus; glumae 5–6 mm longae, 1.5–2.5 mm latae, 2–3-nerves, abrupte acutae, scaberulae, marginibus ciliatis; lemma 6.5–8 mm longum, 3.5–4 mm latum, 5-nerve, subobtusum, scabrum; spiculae femineae uniseriatae; glumae 8 mm longae, 3-nerves, acutae, scaberulae, reticulatae; fructus 6 mm longus apice scaber.

Perennial, with leafy fertile culms; culms 90–130 cm tall, erect from rather short thick rhizomes; lower sheaths longer or shorter than the internodes, the blades obsolete, the upper blade-bearing ones much longer than the internodes, somewhat crowded, auriculate, sparsely fimbriate, glabrous or sparsely pilose; ligule 3 mm long, truncate; blades 15–26 cm long, 4–6 cm wide, acuminate, the lower surface scabrous, the upper glabrous; inflorescence drooping, 20 cm long, 1.3 cm thick; staminate spikelets 6.5–8 mm long, the pedicels hidden, 3 mm long, minutely pubescent; glumes 5–6 mm long, 1.5–2.5 mm wide, 2–3-nerved, abruptly acute, scaberulous, the margins ciliate; lemma 6.5–8 mm long, 3.5–4 mm wide, 5-nerved, subobtuse, scabrous; pistillate spikelets in one row; glumes 8 mm long, 3-nerved, acute, scaberulous, reticulate; fruit 6 mm long, scabrous at the apex.

Type in the U. S. National Herbarium, no. 1613658, collected at edge of forest, Mosqueira, near Belem, Para, Brazil, June 15, 1934, by Jason R. Swallen (no. 4873).

This species of *Pariana* differs from all the others in the conspicuously 5-nerved lemma of the staminate spikelets.

Pariana ovalifolia Swallen, sp. nov.

Perennis; culmi 135 cm alti, basi decumbentes; vaginae inferiores elongatae internodiis breviores laminis valde reductis, superiores internodiis multo longiores, glabrae, reticulatae, in ore sparse fimbriatae; ligula truncata 2–4 mm longa; laminae 17–24 cm longae, 6–7 cm latae, acuminatae, infra pubescentes, supra glabrae, petiolis 5–8 mm longis glabris; inflorescentia pendula, 16 cm longa; spiculae masculae pedicellis 3 mm longis, pubescentibus; glumae 2 mm longae, 1–2-nerves, acutae, pubescentes, marginibus ciliatis; lemma 5–6 mm longum, 2.5–3 mm latum, subobtusum, dense pubescens; spiculae femineae 7 mm longae; glumae aequales, 3-nerves, pubescentes; lemma 6 mm longum, acutum, glabrum apice pubescens.

Perennial; culms about 135 cm tall, erect from a decumbent base, the fertile one leafy toward the summit, bladeless below, glabrous; lower sheaths elongate, shorter than the internodes, the upper crowded, longer than the internodes, glabrous, reticulate-veined, occasionally bearing a few fimbriae at the mouth; ligule truncate, 2–4 mm long; blades 17–24 cm long, 6–7 cm wide, the two uppermost reduced, narrowed toward the base, acuminate, glaucous and pubescent on the lower surface, green and glabrous on the upper, the petiole 5–8 mm long; inflorescence slender, drooping, 16 cm long, the whorls of spikelets distant, not overlapping in the lower part, gradually becoming more crowded toward the summit, but the staminate florets never obscuring the pedicels of the staminate spikelets in the next higher whorl; staminate spikelets 5–6 mm long, the pedicels 3 mm long, pubescent, especially at the base and on the margins; glumes 2 mm long, 1 mm broad at the base, 1 or sometimes 2-nerved, acute, more or less pubescent, the margins ciliate; lemma 5–6 mm long, 2.5–3 mm wide, subobtuse, densely pu-

bescent; fertile spikelet 7 mm long; glumes thin, equal, 3-nerved, pubescent; lemma 6 mm long, acute, pubescent toward the tip, otherwise glabrous.

Type in the U. S. National Herbarium, no. 1614216, collected in forest borders 35 kms north of Monte Alegre, Pará, Brazil, January 28–February 1, 1934, by Jason R. Swallen (no. 3379).

Pariana ovalifolium belongs to the *Foliosae* group in which the fertile culms are leafy. It is most closely related to *P. lunata* Nees, which is a much smaller plant, about half as high, with smaller lanceolate rather than oval blades, which are broad and rounded at the base.

Pariana aurita Swallen, sp. nov.

Perennis; culmi biformes, erecti vel basi decumbentes. Culmi steriles ad 80 cm alti in parte superiore foliosi, scabri; vaginae inferiores internodiis multo breviores, superiores internodiis multo longiores, carinatae, auriculatae; ligula 8–15 mm longa; laminae 15–28 cm longae, 3.5–5.8 cm latae, acuminatae vel subattenuatae, glabrae vel scaberulae, petiolis crassis, 7–10 mm longis, pubescentibus. Culmi fertiles graciles, 50 cm alti, glabri; vaginae internodiis longiores laminis obsoletis; ligula curta; inflorescentia 12 cm longa, gracilis, pendula; spiculae masculae 4 mm longae, pedicellis 2–4 mm longis, pubescentibus vel pilosis, marginibus ciliatis; glumae 2.5–3 mm longae, angustae, acuminatae, 1–2-nerves; lemma 4 mm longum, 1.5 mm latum, reticulatum, scaberulum; antherae ±12, lineares, 2.5 mm longae; spiculae femineae biseriatae 6 mm longae; glumae 1-nerves, acutae, pubescentes, marginibus ciliatis; lemma 5 mm longum, apice minute pubescens.

Perennial; culms erect or somewhat decumbent at the base. Sterile culms 80 cm tall, leafy in the upper fourth; lower sheaths bladeless, much shorter than the internodes, rounded on the back, the upper ones crowded, much longer than the internodes, distinctly keeled, glabrous; ligule 8–15 mm long, joined at the base with the conspicuous auricles of the sheaths; blades 15–28 cm long, long-acuminate, narrowed toward the base, glabrous or scaberulous; fertile culms 50 cm tall, the bladeless sheaths mostly longer than the internodes, rounded on the back, glabrous; ligule very short or wanting; inflorescence drooping, 12 cm long, the whorls of spikelets scarcely overlapping; staminate spikelets 4 mm long, the pedicels conspicuous, 2–4 mm long, sometimes fused toward the base, pubescent or pilose, the margins ciliate; glumes 2.5–3 mm long, usually 1 or sometimes 2-nerved, acuminate, rather narrow at the base, glabrous or minutely pubescent, the margins very shortly ciliate; lemma 4 mm long, 1.5 mm wide, finely reticulate-veined, scaberulous; anthers ±12, linear, 2.5 mm long; pistillate spikelet 6 mm long, the glumes acute, 1-nerved, pubescent, narrower than the mature fruit; fruit 5 mm long, the lemma minutely pubescent near the tip and on the lateral nerves.

Type in the U. S. National Herbarium, no. 1539376 collected in dense forest at the mouth of the Rio Santiago, above Pongo de Manseriche, Department Loreto, Peru, November 17, 1931, by Ynes Mexía (no. 6116).

P. aurita is a very striking species, which is probably most closely related to *P. gracilis* Doell, resembling it in the slender inflorescence of rather distant whorls of spikelets. However, *P. gracilis* has fewer, much smaller blades 10–15 cm long, and a ligule only 2–2.5 mm long.

Pariana distans Swallen, sp. nov.

Perennis; culmi difformes e rhizomatibus erecti, scabri. Culmi steriles 40 cm alti in parte superiore foliosi; vaginae inferiores laminis obsoletis inter-

nodiis breviores, superiores internodiis longiores, pubescentes; ligula truncata, 2 mm longa, pubescens; laminae 10–15 cm longae, 1.8–2.5 cm latae, lanceolatae, acuminatae, infra scaberulae supra pubescentes. Culmi fertiles 40 cm alti, infra inflorescentiam dense pubescentes; vaginae internodiis longiores, glabrae, laminis obsoletis; inflorescentia 9.5 cm longa, erecta, verticillis spicularum remotis; spiculae masculae 7 mm longae pedicellis 3 mm longis, dense pubescentibus; glumae 4–5 mm longae, 3-nerves, scabrae, marginibus ciliatis; lemma 7 mm longum, 2.5 mm latum, pubescens; spiculae femineae incognitae.

Perennial; culms numerous, erect from rhizomes, about 40 cm tall, scabrous. Sterile culms leafy toward the summit, the lower sheaths bladeless; lowermost sheaths short, longer than the internodes, the one of the midculm elongate, shorter than the internode, the upper bladebearing sheaths again longer than the internodes, glabrous or minutely pubescent; ligule truncate, about 2 mm long, pubescent; blades oblong-lanceolate, 10–15 cm long, 1.8–2.5 cm wide, acuminate, shortly soft pubescent on the lower surface, scaberulous above, the petiole 2 mm long, pubescent. Fertile culms densely pubescent below the inflorescence; sheaths all longer than the internodes, bladeless, the uppermost one elongate, glabrous; inflorescence 9.4 cm long, erect, the whorls of spikelets rather distant, the staminate florets scarcely reaching the base of the pedicels of the staminate spikelets of the whorl above; pedicels of the staminate spikelets 3 mm long, densely pubescent, more or less fused together; glumes 4–5 mm long, 3-nerved, acute, scabrous, the margins shortly ciliate; lemma 7 mm long, 2.5 mm wide. pubescent; pistillate spikelet undeveloped.

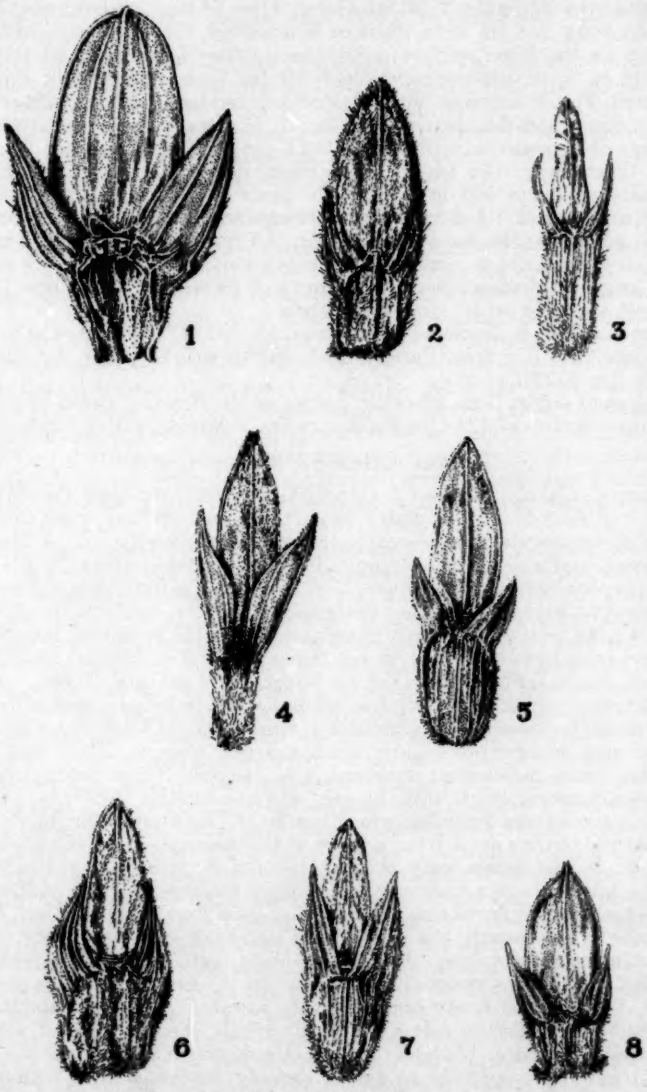
Type in the U. S. National Herbarium, no. 1614187, collected in forest borders, Santarem, Pará, Brazil, January 19–26, 1934, by Jason R. Swallen (no. 3286).

This species differs from all the others in the *Graciles* group in the 3-nerved glumes of the staminate spikelets and the longer staminate lemma. In the other species of this group the glumes of the staminate spikelets are only 1-nerved (rarely 2-nerved), and the lemmas are not more than 5.5–6 mm long.

Pariana ligulata Swallen, sp. nov.

Perennis; culmi difformes caespitosi, erecti, basi decumbentes. Culmi steriles 70–95 cm alti, in parte superiore foliosi; vaginae inferiores internodiis breviores laminis obsoletis, superiores internodiis multi longiores, carinatae; ligula 6–10 mm longa, firma, obtusa vel truncata; laminae 15–32 cm longae, 3–4 cm latae, subattenuatae, reticulatae, petiolis crassis, 6–10 mm longis glabris vel minute pubescentibus. Culmi fertiles 50–60 cm alti, laminis obsoletis; vaginae internodiis longiores; inflorescentia 12 cm longa, pendula, parte inferiore in vagina suprema inclusa, verticillis spicularum approximatis; spiculae masculae 5–6 mm longae, pedicellis 4–5 mm longis sparse pubescentibus; glumae 1.5–2 mm longae, 1–2-nerves, triangulae, acutae, scabrae; lemma 5–6 mm longum, 2–2.5 mm latum, 3-nerve, acutum, reticulatum, scabrum; antherae lineares, 3 mm longae; spiculae femineae 9 mm longae; glumae 1–3-nerves acutae vel subacuminatae, scabrae; lemma 7 mm longum, acutum, subapiculatum.

Perennial; culms in rather large spreading clumps, erect from a decumbent base. Sterile culms 70–95 cm tall, leafy in the upper half; sheaths elongate, the lower ones a little shorter than the internodes, the upper ones longer than the internodes but scarcely crowded, keeled toward the summit,



Figs. 1–8.—Front view of staminate spikelets of new species of *Pariana*, showing the pedicel, glumes, and lemma, ×5: 1, *P. nervata;* 2, *P. ovalifolia;* 3, *P. aurita;* 4, *P. distans;* 5, *P. ligulata;* 6, *P. sociata;* 7, *P. modesta;* 8, *P. velutina.* All drawings made from the type specimens by Mrs. Frances C. Weintraub.

reticulate-veined; ligule 6–10 mm long, firm, obtuse or truncate; blades 15–32 cm long, 3–4 cm wide, more or less plaited, the transverse veins conspicuous on the lower surface, acuminate, narrowly rounded at the base, glabrous on both surfaces; petiole 6–10 cm long, glabrous or minutely pubescent. Fertile culms 50–60 cm tall, nearly hidden under the foliage of the sterile culms; sheaths somewhat inflated, all longer than the internodes, bladeless or sometimes with blades 1–2.5 cm long; inflorescence drooping, about 12 cm long, the whorls of spikelets distant, scarcely overlapping; staminate spikelets 5–6 mm long, the pedicels 4–5 mm long, sparingly pubescent; glumes 1.5–2 mm long, triangular, acute, 1 or sometimes 2-nerved, scabrous; lemma 5–6 mm long, 2.5 mm wide, strongly 3-nerved, reticulate-veined above, scabrous; anthers about 3 mm long; fertile spikelet 9 mm long, the glumes 1-nerved, scabrous or pubescent at the base; fruit 7 mm long, abruptly acute, almost apiculate.

Type in the U. S. National Herbarium, no. 1613673, collected in forest at Boa Vista, Rio Tapajos, Pará, Brazil, January 7–13, 1934, by Jason R. Swallen (no. 3177).

P. ligulata differs from all other species in the *Graciles* group in the large pistillate spikelets and the long comparatively narrow plaited blades.

Pariana sociata Swallen, sp. nov.

Perennis. Culmi difformes e rhizomatibus erecti vel basi decumbentes. Culmi steriles ±40 cm alti, glabri, in parte superiore foliosi; vaginae glabrae vel in parte superiore pubescentes, inferiores internodiis multo breviores, superiores internodiis multo longiores in ore dense fimbriatae pilis 10–15 mm longis; laminae 8.5–11 cm longae, 1.7–2.7 cm latae, acuminatae, infra minute pubescentes, supra scaberulae, marginibus serratis; ligula truncata 1 mm longa. Culmi fertiles 30 cm alti; vaginae internodiis longiores, inflatae, glabrae vel minute pubescentes, in ore dense fimbriatae, laminis obsoletis vel ad 2 cm longis; inflorescentia 7–8 cm longa, 1–1.3 cm lata, erecta, verticillis spicularum approximatis; spiculae masculae 5 mm longae, pedicellis 4 mm longis dense pubescentibus; glumae 2–3 mm longae, 1–3-nerves, acuminatae, pubescentes, marginibus ciliatis; lemma 5 mm longum, 2.5–3 mm latum, acutum, dense pubescens; antherae ±8, lineares, 2 mm longae; spiculae femineae uniseriatae, 6 mm longae; glumae acutae, 3-nerves, aequales, pubescentes; lemma 5 mm longum, 3 mm latum, acutum, glabrum.

Perennial; culms erect from a more or less decumbent rhizomatous base, glabrous. Sterile culms leafy toward the summit, about 40 cm tall; lower sheaths much shorter than the internodes, bladeless or the blades much reduced, the upper ones crowded, keeled at least toward the summit, densely fimbriate in the mouth, the hairs 10–15 mm long; ligule truncate, 0.5 mm long; blades 8.5 cm long, 1.7–2.7 cm wide, rather abruptly acuminate, rounded at the base, minutely pubescent on the lower surface, scaberulous above, the margins finely but distinctly serrate, the petiole about 1 mm long, pubescent. Fertile culms about 30 cm tall; sheaths inflated, all longer than the internodes, bladeless or sometimes the blade as much as 2 cm long, 1 cm wide, sparsely to rather densely fimbriate at the mouth; inflorescence 7–8 cm long, 1–1.3 cm wide, stiffly erect, the staminate spikelets about half overlapping the pedicels of the staminate spikelets in the whorl above; staminate spikelets 5 mm long, somewhat spreading; pedicels 4 mm long, densely pubescent; glumes 2–3 mm long, 1–3-nerved, acuminate, pubescent, the margins ciliate; lemma 5 mm long, 2.5–3 mm wide, short but densely pubescent; anthers 2 mm long, pistillate spikelet 6 mm long, the

glumes acute, 3-nerved, pubescent; fruit 5 mm long, 3 mm wide, acute, glabrous.

Type in the U. S. National Herbarium, no. 1613672 collected in open sandy forest between Caxias and Barra do Corda, Maranhão, Brazil, February 18–26, 1934, by Jason R. Swallen (no. 3599).

P. sociata is similar in appearance to *P. zingiberina* Doell, which differs in having thicker, shorter blades, almost no fimbriae at the mouth of the sheaths, and smaller glabrous staminate spikelets.

Pariana modesta Swallen, sp. nov.

Perennis; culmi difformes, graciles e rhizomatibus erecti. Culmi steriles 15–35 cm alti, in parte superiore foliosi; vaginae glabrae, inferiores internodiis breviores, superiores internodiis multo longiores in ore fimbriatae; laminae 3–7.6 cm longae, 5–14 mm latae, lanceolatae, minute pubescentes. Culmi fertiles 20 cm alti; vaginae internodiis breviores inflatae, glabrae vel minute pubescentes, laminis obsoletis; inflorescentia 3–4 cm longa, erecta, verticillis spicularum approximatis; spiculae masculae 5 mm longae, pedicellis 4 mm longis; glumae 3–4 mm longae, 3-nerves acutae vel subacuminatae basi latae, pubescentes, marginibus ciliatis; lemma 4.5–5 mm longum, 2 mm latum, 3-nerve, acutum, scaberulum vel pubescens; palea acuta lemma aequans; antherae ±20, 1–1.5 mm longae; spiculae femineae 6 mm longae; glumae aequales, 1–3-nerves, acuminatae, pubescentes; lemma 5 mm longum, acutum.

Perennial; culms slender, erect from rhizomes. Sterile culms 15–35 cm tall, leafy toward the summit, glabrous; lower sheaths much shorter than the internodes, the upper ones crowded, much longer than the internodes, conspicuously fimbriate at the mouth; ligule very short, thick; blades 3–7.6 cm long, 5–14 mm wide, thin, lanceolate, minutely pubescent on both surfaces, the pubescence sometimes obscure. Fertile culms 20 cm tall, glabrous or minutely pubescent; sheaths all shorter than the internodes, inflated, bladeless, never fimbriate; inflorescence 3–4 cm long, bearing 3 or 4 rather distant whorls of spikelets, the whorls scarcely overlapping exposing the pedicels of the staminate spikelets; staminate spikelets 5 mm long, the pedicels 4 mm long, densely pubescent toward the base becoming nearly glabrous at the summit; glumes 3–4 mm long, strongly 3-nerved, acute or subacuminate, broad at the base, more or less pubescent, the margins ciliate; lemma 4.5–5 mm long, 2 mm wide, 3-nerved, abruptly acute, scaberulous and more or less pubescent; palea acute, equaling or slightly exceeding the lemma; anthers about 20, 1–1.5 mm long; pistillate spikelet 6 mm long, the glumes equal, acuminate, 1–3-nerved, pubescent, the lemma 5 mm long, acute, rather broad, almost entirely enclosing the palea.

Type in the U. S. National Herbarium, no. 1613666, collected in high open forest between Caxias and Barra do Corda, Maranhão, Brazil, February 18–26, 1934, by Jason R. Swallen (no. 3544).

In the region where the type was collected, this species was very abundant, in some cases being the dominant herbaceous plant in moist open woods called "Carasco." The fertile culms were never plainly evident being obscured under the foliage of the sterile culms, the young ones even hidden in the ground cover of old leaves. Only a small proportion of the plants had fertile culms at the time the specimens were collected.

DISTRIBUTION: Open forests, east-central Maranhão, Brazil. Between Caxias and Barra do Corda, *Swallen* 3597, 3544 (type); Barra do Corda to Grajahu, *Swallen* 3631; Carolina to San Antonio de Balsas, *Swallen* 4132.

This species was found growing with *P. sociata* and resembles it in several ways, especially in having thin blades, numerous fimbriae, and a short erect inflorescence. It differs, however, in being a much smaller plant with short narrow blades, short slender inflorescences of distant whorls of smaller glabrous staminate florets, the glumes of which are very broad at the base, strongly 3–5-nerved.

Pariana velutina Swallen, sp. nov.

Perennis; culmi difformes basi adscendentes. Culmi steriles 45–50 cm longi infra nodos dense pubescentes; vaginae inferiores obsoletae, mediae elongatae internodiis breviores laminis obsoletis, superiores foliatae internodiis multo longiores, auriculatae, fimbriatae, carina dense pubescente; laminae 12–16 cm longae, 2–4.6 cm latae, lanceolatae vel ovato-lanceolatae, acuminatae, infra dense pubescentes, supra glabrae nervo medio dense hirtello. Culmi fertiles graciles, 25 cm longi, infra inflorescentiam dense pubescentes; vaginae 2 vel 3, internodiis breviores, inflatae, glabrae; alaminis obsoletis; inflorescentia erecta 6 cm longa; spiculae masculae 4.5 mm longae, pedicellis occultis 2–2.5 mm longis pilosis basi villosis; glumae 2–2.5 mm longae, 1 mm latae, 1–2-nerves, acutae vel acuminatae, scabrae; lemma 4.5 mm longum, 1.5–2 mm latum, 3-nerve, acutum, scabrum, basi pubescens; antherae 2.5 mm longae; spiculae femineae uniseriatae; glumae 5 mm longae, 1–3-nerves, acutae vel subobtusae, pubescentes; fructus 5 mm longus, 3 mm latus, glaber, superne pubescens.

Perennial; culms biform, erect from an ascending base. Sterile culms 45–50 cm long, densely pubescent below the nodes; lowest sheaths obsolete, the median one elongate, shorter than the internodes, the blades obsolete, the upper leaf-bearing ones crowded, much longer than the internodes, auriculate, fimbriate, densely pubescent on the keel; blades 12–16 cm long, 2–4.6 cm wide, lanceolate or ovate-lanceolate, acuminate, softly pubescent on the lower surface, glabrous on the upper surface, the midnerve densely hirtellous. Fertile culms slender, 2.5 cm long, densely pubescent below the inflorescence; sheaths 2 or 3, shorter than the internodes, inflated, glabrous, the blades obsolete; inflorescence erect, 6 cm long; staminate spikelets 4.5 mm long, the pedicels hidden, 2–2.5 mm long, pilose, densely villous at the base; glumes 2–2.5 mm long, 1 mm wide, 1–2-nerved, acute or acuminate, scabrous; lemma 4.5 mm long, 1.5–2 mm wide, 3-nerved, acute, scabrous, pubescent toward the base; anthers 2.5 mm long; pistillate spikelets in one row; glumes 5 mm long, 1–3-nerved, acute or subobtuse, pubescent; fruit 5 mm long, 3 mm wide, glabrous, pubescent toward the summit.

Type in the U. S. National Herbarium, no. 1458908, collected at Gamitanacocha, Río Mazán, Department Loreto, Peru, altitude 100–125 meters, by Jose M. Schunke (no. 164).

Pariana trichosticha Tutin is the only other species that has the midnerve of the blades hirtellous on the upper side but differs from *P. velutina* in having glabrous blades, densely pubescent sheaths, and longer glumes on the pistillate spikelet (7 mm long), which extend beyond the fruit.

BOTANY.—*New varieties and new combinations in the genera* Clausena, Oxanthera, *and* Triphasia *of the orange subfamily, Aurantioideae.*[1] WALTER T. SWINGLE, U. S. Bureau of Plant Industry.

In connection with the preparation of a synopsis of the orange subfamily, soon to be published, I have brought to light a number of new genera, species, and varieties. I have already published a paper on my new taxonomic arrangement of the subfamily.[2]

I have had the good fortune to be able to borrow from several of the great herbaria of Europe, Asia, and the United States a large number of specimens of the species of *Clausena* and of other genera of the subfamily Aurantioideae. Thanks to the use on a large scale of the modified Juel method[3] of restoring herbarium material of flowers, young fruits, etc., and making serial microtome sections of them, I have been able, with the skilled help of Dr. Albert H. Tillson, to throw new light on some of the taxonomic problems that have arisen in separating the numerous and often highly variable species of some of the genera of this subfamily.

Genus CLAUSENA Burm.

Clausena luxurians (Kurz) Swingle, comb. nov.

Clausena Wallichii Oliv. var. *luxurians* Kurz, Journ. Asiat. Soc. Bengal **44** (2): 133. 1876.

Clausena Wallichii affinis sed differt (1) foliis multo grandioribus, (2) foliolis grandioribus et multo paucioribus, (3) floribus minoribus, (4) partes florales sine cellulis residuiis tanniniferis repletis, (5) alis petiolis duplo latioribus, (6) marginis foliorum integris vel leviter crenulatis nec denticulatis, (7) foliolis in sicco pallido-viridis, nec fusco-viridis.

A small, meagre shrub, leaves large, 33–50 by 20–27 cm, 5–7- (often 6-) foliolate, leaflets lanceolate or broadly oval, variable in size, lower lateral leaflets 6.5–7.5 by 4–5 cm, upper lateral and terminal leaflets 15–21 by 6.5–9.5 cm, larger leaflets acuminate or broad-acuminate at the apex, variably cuneate at base and decurrent into the petiolules, lateral veins variable in prominence, larger ones few, 7–9, arising at angles of 70–75° with the midrib, the intermediate, fainter and shorter ones often arising at greater angles (80–89°!), margins entire or slightly crenulate; rachis narrowly winged, wings 0.8–1.5 mm wide on each side of the rachis; inflorescences terminal, paniculate; flowers small, 4–5 mm in diameter, 4-(or 5-?) merous, borne on short pedicels, 1–2 mm long with minute ciliate bracts at the base, calyx lobes acute, with a large oil gland at the tip (not seen in Fig. 1 but visible in other sections on the same slide), anthers with a small oil gland in the connective, pistil (including gynophore) 2.5–2.8 mm long, ovary 1–1.1 mm long,

[1] Received January 6, 1940.

[2] SWINGLE, WALTER T. *A new taxonomic arrangement of the orange subfamily, Aurantioideae.* Journ. Washington Acad. Sci. **28**: 530–533. 1938.

[3] See SWINGLE, WALTER T. *New methods utilized in studying the taxonomy of the orange subfamily.* Journ. Washington Acad. Sci. **29**: 270. 1939.

1–1.3 wide, with one medium-sized protuberant oil gland at the tip of each locule, style 1.3 mm long, cylindrical, 0.5–0.6 mm in diameter, except at the base, which is 0.3 mm in diameter, where it joins the ovary; stigma not delimited from the style; fruits (immature) globose, 5–6 mm in diameter.

Type specimen.—Burma, rare in eastern slopes of Pegu Yomah in tropical forests, *Sulpiz Kurz* 1995, flowering branches, Herb. Roy. Bot. Gard. Calcutta; photographs and serial sections, S. & T. Nos. 519 A, slides 1–4 (168 cross sections of a flower bud), 519 B 1, and 519 C 1 (95 longitudinal sections of 2 pistils), Herb. National Arboretum.

Fig. 1.—*Clausena luxurians:* Serial longitudinal sections of pistil of type specimen. ×10.

Cotype specimen.—Same locality, *Kurz* 1995, "Choungmerah Chg.," Herb. Roy. Bot. Gard. Calcutta; photographs and serial microtome sections, S. & T. Nos. 520 A, slides 1–4 (198 cross sections of 1 flower bud), 520 B 1, 520 C 1 (76 longitudinal sections of pedicel, calyx, and pistil), Herb. National Arboretum.

Remarks.—The original description of *Clausena Wallichii* var. *luxurians* by Kurz is very short; it reads, in full: "*Clausena Wallichii* Oliv. Var. *β luxurians*, rachis leafy-winged; leaflets only 4–2 pairs with an odd one, 4–8 in. long, remaining green in a dried state."

The leaves of this species differ markedly from those of *C. Wallichii* in having much larger, broader, and fewer leaflets (5–7 instead of 13–17!). On the other hand, the flowers of *C. Wallichii* (which has much smaller leaflets) are decidedly larger, the pistil being from one-fifth to one-quarter longer and the style nearly two-thirds longer!

Another species, *C. Guillauminii*, native to French Indochina, resembles *C. luxurians* and *C. Wallichii* in having leaves with narrowly winged rachis and also has flower parts not greatly different from those of *C. Wallichii;* it is, however, strikingly different from both of them in having dimorphic oil glands in the leaves, many very small ones, and a few very large ones, ¼ to ½ mm in diameter, clear bright red by transmitted light. These three species are doubtless descended from a common ancestral form but have diverged so much in taxonomic characters that they are now good, easily distinguishable species.

One of the most striking characters of *C. luxurians*, in which it differs markedly from all species at all closely related to it, is the almost complete absence in the flower parts of tissue cells filled with brownish, nearly opaque tannin residues that occur in abundance in all the other species of *Clausena* except *C. suffruticosa*, a very aberrant species; *C. dentata* var. *longipes* has

such cells but only a few of them; note the contrast between Figs. 1 and 2 in this respect.

C. luxurians in its general aspect, flower morphology, and especially in its leaf characters, somewhat resembles *C. heptaphylla* of British India, Burma, Indochina, and Malaya, but the leaves of this latter species do not have a winged or margined rachis and have floral organs with abundant cells filled with tannin residues. The many-sided affinities of this newly recognized species are characteristic of the situation found among the many closely related species of this large genus.

Fig. 2.—*Clausena Wallichii:* Serial longitudinal sections of pistil. *Burkill* 30288, Amherst Distr. Burma, Herb. Bot. Gard. Calcutta. ×10.

Clausena dentata var. **Henryi** Swingle, var. nov.

A typo differt (1) fructu ovoideo nec sphaerico, negro, (2) foliis foliolisque duplo majoribus hirsutioribus, (3) petalis hirsutis, (4) foliolis lateralibus superioribus saepe grandioribus quam folioli terminales.

Type specimen.—China, Ichang, *Henry* 4122, flowering branch, May 1888, Herb. Kew Gardens; photograph and serial microtome sections, S. & T. Nos. 528 A, slides 1–3; 528 B, slides 1–3 (381 cross sections of flower bud); 528 C 1 and D 1 (85 longitudinal sections of two pistils); Herb. National Arboretum.

Cotype specimen 1.—China, Ichang, *Henry* 3127, February 1887, fruiting branch, Herb. Kew Gardens; photograph Herb. National Arboretum.

Cotype specimen 2.—China, Ichang, *Henry* 13028, Herb. Kew Gardens; photograph and serial microtome sections, S. & T. No. 538 A, slides 1–3, B 1–3. (336 cross sections from 2 flower buds); C 1, D 1 (105 longitudinal sections from 2 flower buds); Herb. National Arboretum.

Serial microtome sections made from a flower bud of the type specimen (*Henry* 4122) show the flowers to be tetramerous; the anthers show small oil glands in the connective, obscured by dense tannin residues in the surrounding cells; total length of pistil from calyx to tip of stigma 4–4½ mm, gynophore hourglass-shaped, 0.6–0.7 mm high, ovary 1–1.2 mm high, 1.1–1.3 mm

wide, with a minute, slightly protuberant oil gland at the top of each locule, style 1.2–1.3 mm long, subclavate, 0.5–0.6 mm wide at base where it joins the ovary, gradually expanding toward the tip where it is 0.7–0.8 mm wide; stigma not clearly delimited.

Remarks.—This striking variety of *C. dentata* (Willd.) Roemer has been identified wrongly as *C. suffruticosa* (Roxb.) Wight, which is a very different plant which has been confused with Henry's *Clausena* doubtless because of its rather slender ovoid fruits. The fruits of *C. dentata* var. *henryi*, 9–12 by 6–8 mm, black when ripe and said to be edible, are very different from the fruits of the typical *C. dentata* of British India, which when ripe are globose, whitish green, and about 8–12 mm in diameter. Henry's *Clausena* has the northernmost range yet reported for any species of the genus. It grows near Ichang, Hupeh Province, China, about latitude 31° N. Many varieties of *C. dentata* have been described, but most of them are still inadequately known. Another Chinese variety of this species, *C. dentata* var. *robusta* Tanaka, is a vigorous plant having rather small globose fruits, 7–8 mm in diameter.

Still another Chinese variety very inadequately described and named by Léveillé as a distinct species, *C. Dunniana* Lev., can better be considered a variety of *C. dentata*.

Clausena dentata var. Dunniana (Lev.) Swingle, comb. nov.

Clausena Dunniana Léveillé, in Fedde's Report. **10**: 67. 1912.

Type specimen.—Pin-fa, Kweichow Province, China, *J. Cavalerie* 1072, Herbarium of Edinburgh University; photograph in Herb. National Arboretum.

Cotype specimen 1.—Same locality, *J. Cavalerie* 1072, June 18, 1903, flowering branch, Herb. Kew Gardens.

Cotype specimen 2.—Same locality, *J. Cavalerie* 1072, flowering branch, Herb. Univ. Edinburgh; photograph and fragments ex Herb. Monseigneur Léveillé, in Herb. Arnold Arboretum.

This plant is still very little known, as Léveillé's description was very short. It looks much like some specimens assigned to *Clausena dentata* var. *robusta* Tanaka, and more study is needed to separate these two poorly characterized varieties. Some specimens of *C. dentata* var. *Dunniana* have petiolules 4–6, rarely 8, mm long, longer than have been seen on any other Chinese forms of *C. dentata*.

Clausena brevistyla var. halmaheirae (Miq.) Swingle, comb. nov.

Clausena halmaheirae Miquel, Ann. Mus. Bot. Lugd.-Bat. **1**: 211. 1863.

This variety has diminutive pistils, only 1.4–1.5 mm long, with the gynophore only 0.2–0.3 mm long, the ovary 0.8 mm long and 0.8 mm wide, rough with oil glands, the style 0.5–0.6 mm long and cylindrical. The inflorescences are large, 25–35 cm long, with widely spreading primary branches and sturdy terminal pedicels, 2–4 mm long.

The above measurements were taken from serial microtome sections made from a topotype specimen from Halmaheira Island (*Teysmann* 5667) in Herb. Roy. Bot. Garden Calcutta.

The styles are slightly longer than those of *C. brevistyla* but otherwise similar.

The southernmost species of *Clausena*, *C. brevistyla* Oliver, native to northeastern Australia, has, as its name indicates, a very short style, less than one-half as long as the ovary. It now appears that a species described from Halmaheira (or Gilolo) Island in the Moluccas, *C. halmaheirae* Miq.,

also has a very short style and doubtless belongs close to *C. brevistyla* and can best be made a variety of it.

Genus OXANTHERA Montr.

Oxanthera is a genus of the *Wenzelia* group of the subtribe Triphasiinae, tribe Citreae. It is limited to New Caledonia and with the species here transferred to the genus has four species with large orangelike flowers but with no pulp-vesicles in the fruit. This excludes them not only from the genus *Citrus* but from the whole subtribe Citrinae.

Oxanthera undulata (Guill.) Swingle, comb. nov.

Citrus undulata Guillaumin, Bull. Soc. Bot. France **85**: 304. 1938.

This species has thin leaves unlike the other three, which have thick, more or less coriaceous leaves. This seems to indicate they are more or less pronounced xerophytes, whereas *C. undulata* is more likely a mesophyte.

All the species of this very curious genus are discussed in some detail in my synopsis of *Citrus* and related genera of the orange subfamily, now in press.

Genus TRIPHASIA Lour.

The genus *Triphasia* is a small one that has been known to botanists for several centuries and is the type of the subtribe Triphasiinae of the tribe Citreae. The best-known species is *Triphasia trifolia* with trifoliate leaves, small white flowers, and tiny red berries, often grown in hothouses and in subtropical gardens as an ornamental plant.

Recently an autotetraploid form of this species was discovered in the U. S. Bureau of Plant Industry citrus greenhouse.

Triphasia trifolia var. **tetraploidea** Swingle, var. nov.

A typo differt (1) chromosomatis duplo numerosioribus in omnibus cellulis (autotetraploideis), (2) foliis paulo crassioribus, floribus paulo grandioribus.

Type specimen.—Washington, D. C., citrus greenhouses, U. S. Bureau of Plant Industry, *Swingle* C.P.B. No. 2889, P.E.I. 27778, fruiting branch, S. & T. No. 575, slide 1, numerous pollen mother cells showing tetraploid chromosomes, made by Dr. A. E. Longley, March 3, 1937; Herb. National Arboretum, No. 70839.

Remarks.—This variety differs from the species in having larger flower parts and thicker leaves, and especially in having 36 chromosomes in all the somatic cells instead of 18, the normal number for almost all the plants of this orange subfamily so far studied.

This autotetraploid form of the common trifoliate limeberry looks much like tetraploid forms of *Citrus*, having, like them, thicker leaves and larger flower parts. Longley,[4] who has studied the chromosome numbers of *Citrus* and many related genera, first detected the tetraploid nature of this plant. This variety doubtless originated as a mutation from the common diploid form of the species. This tetraploid form of the common limeberry is a vigorous plant that flowers and fruits freely in the greenhouse. It may prove to have value in ornamental plantings both in the hothouse and in subtropical gardens.

[4] LONGLEY, ALBERT E. *Polycarpy, polyspory, and polyploidy in citrus and citrus relatives.* Journ. Washington Acad. Sci. **15**: 347–351, 1 fig. 1925.

ZOOLOGY.—*A new pycnogonid from Pescadero, Calif., and distributional notes on other species.*[1] JOEL W. HEDGPETH. (Communicated by WALDO L. SCHMITT.)

The pebble beach near Pescadero, Calif., is not a good collecting ground for marine invertebrates, since the reef is somewhat like a sea wall, but it is the only habitat so far known of a hitherto undescribed species of *Ammothea*. A specimen of this pycnogonid was collected in September 1930, and when the beach was revisited in August 1939 three more specimens were taken from the same small area of the reef at the south side of the pebble beach cove. The recent collection was made from worn eelgrass holdfasts just below the *Littorina scutulata* horizon at a 2.8 tide (about the upper limit of zone 3 of the classification of Ricketts and Calvin, 1939), which is a rather high distribution for littoral pycnogonids on the California coast and supports Giltay (1934) in his contention that the genus *Ammothea* is composed of littoral forms adapted to various biotopes and that a large number of species are still to be discovered in regions not yet carefully investigated for pycnogonids.

Ammothea euchelata, n. sp. Fig. 1

Holotype.—Male, with egg clusters. Pescadero, Calif., August 15, 1939. U.S.N.M. no. 78411.

Paratypes.—One male, in U.S.N.M. collections; egg-bearing male, dissected, in author's collection.

Description.—Body circular, about 1.5 mm in diameter, lateral processes contiguous but not fused, with low tubercles on the anterior and posterior distal corners of the processes. Proboscis ovoid, directed ventrally, not quite so long as trunk. Eye tubercle near anterior border of first trunk segment, low and without spines or projections; eyes large and distinct. Abdomen moderately long, about twice the length of the lateral processes of the last pair of legs, with a few small spines near the apex. Chelifores nearly as long as the proboscis although apparently a little over half as long; scape stout, little more than half the length of the chelifore; chelae well developed, subglobular, the fingers broadly curved so that only the tips oppose, without teeth or setae. Palpus slightly longer than proboscis, first joint short, about equal to third joint; second joint slightly longer than first and third combined; fourth joint about equal to second; last four joints short, more or less equal, together a little longer than the fourth; joints 5, 6, and 7 with ventral processes, terminal joint oval, a few setae on the ventral processes and on the distal portion of the terminal joint. Oviger of male about twice as long as palpus, first joint short, stout; second joint three times as long as wide; third joint slightly longer than second but half the diameter; joints 4 and 5 equal, shorter than the third; joint 6 one-half as long as 5, joints 5 and 6 with spines on outer margin directed backward; joints 7, 8, and 9 nearly equal, 7 and 8 stout, 9 slender; terminal joint short and blunt. The last four segments of the oviger bear a spine with teeth on its inner

[1] Received September 20, 1939.

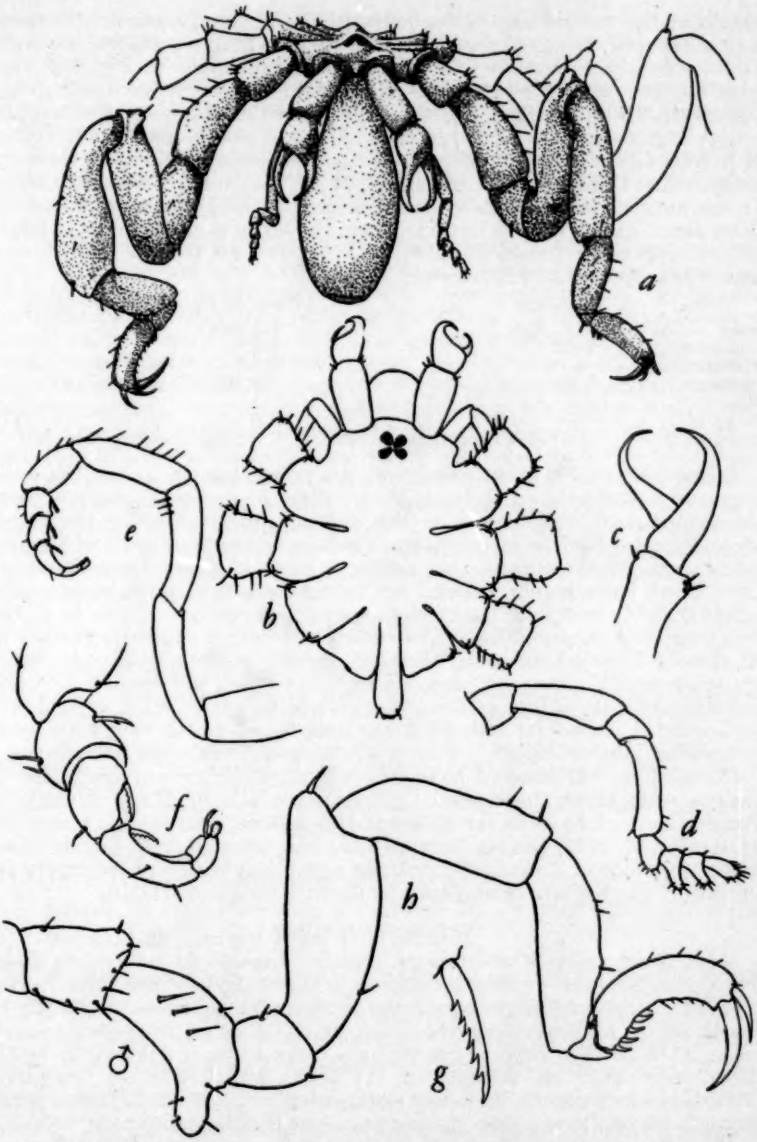


Fig. 1.—*Ammothea euchelata*, n. sp.: *a*, Front view of holotype, ×30; *b*, dorsal view of trunk of holotype, ×30; *c*, ventral view of right chelifore of paratype, ×45; *d*, right palpus of paratype, ×45; *e*, right oviger of paratype, ×45; *f*, detail of terminal joints of oviger, ×120; *g*, denticulate spine from oviger, ×1,000; *h*, right third leg of paratype, ×33. (All drawings made with the aid of a camera lucida; magnifications approximate.)

margin at the ventral base of the joint. In the terminal segment this spine is sickle-shaped, situated near the distal ventral margin, and on the slide mount obscures a minutely lobed leaflike terminal spine. In Fig. 1, *f*, this spine has been drawn away to reveal the structure of the terminal spine. Eggs about 0.1 mm in diameter, in small scattered masses of 12–20 along the oviger. Legs stout, comparatively short; first and second coxal joints armed with spines laterally; genital protuberance of second coxa of male very conspicuous; third coxa and remainder of leg with a few scattered spines. Tarsus curved, terminal claw strong, nearly as long as tarsus, auxiliary claws about half as long as terminal claw. Proportions of the joints in millimeters approximately as follows: 0.5, 0.5, 0.5, 1.0, 1.0, 0.8, 0.25, 0.5. Measurements (approximate) as follows:

	Holotype	*Paratype* (from dissected parts)
Body	1.5 mm	1.5 mm
Proboscis	1.25	1.0
Abdomen	—	0.6
Chelifore	1.0	1.0 (scape 0.6, chela 0.4)
Palpus	—	1.5
Oviger	—	2.0
Third leg	2.5 (from above, unextended)	5.0 (sum of segments)

Relationships.—No other species of *Ammothea* known to me has such large and well-developed chelae in the adult as *A. euchelata*, and this character separates it from the rest of the California species, in which the chelae are rudimentary knobs in the adult. The ventral protuberances of the terminal segments of the palpus are similar to those of *Ammothea pribilofensis* Cole, which has a higher, pointed eye tubercle and a broader, blunter proboscis than *A. euchelata*. Denticulate spines occur only on joint 10 of the male oviger of *A. pribilofensis*. *Ammothea euchelata* is evidently related to *A. spinosa* (Wilson), in which the chelifores are sometimes chelate. They are much smaller, however, and the legs as a whole are spinier. The terminal joints of the palpus of *Ammothea spinosa* do not have the ventral projections of *A. euchelata*, and the denticulate spines of the oviger are symmetrical and the proportions of the joints themselves different in *A. spinosa*.[2]

Distribution.—Although I have collected intensively for pycnogonids at various reefs along the central California coast from Marin County to Pacific Grove, I have so far collected this species only at Pescadero. On September 30, 1930, one egg-bearing male was collected from *Bugula* along with a specimen of *Ammothea gracilipes*, apparently the southern record for the latter, which is most abundant just north of the Golden Gate.

DISTRIBUTION NOTES

Moss Beach, San Mateo County, Calif.—*Ammothella tuberculata* Cole, five specimens, from eelgrass holdfasts and among hydroids on pitted rocks, 2–11–34. *Lecythorhynchus marginatus* Cole, four specimens, 4–23–32; 12 specimens, including egg-bearing males, on *Abietinaria*, 2–10–34; six specimens, 11–6–38. *Tanystylum intermedium* Cole, three specimens, 2–10–34; three specimens, on *Abietinaria*, 11–6–38. *Phoxichilidium femoratum* (Rathke), 10 specimens, including egg-bearing males, 4–23–32; three specimens, 2–10–34. *Pycnogonum stearnsi* Ives, one female, under rock, 3–26–32.

Muir Beach, Marin County, Calif.—*Ammothea gracilipes* Cole, 12 specimens, including egg-bearing males, from *Bugula*, *Abietinaria*, and pitted rocks, 5–11–33. *Ammothella tuberculata* Cole, one specimen, 5–23–32; three

[2] *Ammothea acheloides* Wilson (Pl. 5, Fig. 1) = *A. spinosa*, auctoritate Schimkewitsch.

specimens, 5–11–33; one specimen, April 1934. *Lecythorhynchus marginatus* Cole, 12 specimens, including egg-bearing males, from *Abietinaria*, 5–11–33; 12 specimens, including egg-bearing males, from *Abietinaria*, April 1934. *Tanystylum intermedium* Cole, 14 specimens, including egg-bearing males, from *Abietinaria*, April 1934. *Pycnogonum stearnsi* Ives, three males from *Abietinaria*, April 1934.

Jenner, Sonoma County, Calif. (near Bodega Bay).—Ammothea gracilipes Cole, one female, and *Pycnogonum stearnsi* Ives, one female, both from *Campanularia*, collected by A. R. Grant, February 1934.

It will be noted in the Moss Beach collections that in 1932 *Phoxichilidium femoratum* was common and *Lecythorhynchus marginatus* was scarce, but that the situation was reversed in 1934. Unfortunately it was not possible to make regular collections to determine if this is a case of periodicity or simple coincidence. At Muir Beach, *Lecythorhynchus marginatus* and *Tanystylum intermedium* were collected from the same fronds of *Abietinaria* in equal numbers. These two species and *Pycnogonum stearnsi* occur in the *Abietinaria* along the sheltered rock wall at the north border of the beach, while *Ammothea gracilipes* occurs in hydroids and bryozoan colonies among the maze of large boulders that marks the south border of the Muir Beach cove. There is some variation in the length of the protuberance on the dorsal part of the second coxal joint in this species, in some specimens being as long or longer than the coxal segment. There was no variation observed in the direction of increased body size and reduction of these protuberances as described by Lozina-Lozinsky (1933) in his variety *borealis* of *Ammothea gracilipes* from the Gulf of Kastri.

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ZOOLOGY.—*A new trematode from* Siren lacertina: Diplostomulum sirenis, *n. sp.*[1] GEORGE C. KENT, JR., Vanderbilt University. (Communicated by PAUL BARTSCH.)

A number of *Siren lacertina* (Linnaeus), collected from marshes along the banks of the Cumberland River, near Nashville, Tenn., in October 1938, were kept in an aquarium until May 1939, when the animals were sacrificed for routine histological examination. Of four specimens examined (all that were available), three (length approximately 25 cm) were found to be infected with a trematode, herein described as a new species of the genus *Diplostomulum*. Over 100 specimens were obtained from one host, 50 from a second, 6 days

[1] Received October 27, 1939.

later, and 30 from a third, 13 days after the first animal was sacrificed. The fourth animal (14 cm) did not appear to be infected. The Diplostomula were not encysted but were free in the pericardial cavity, where they were clumped in a white mass about the ventricle. Inspection of the alimentary tract and of the great vessels revealed no similar forms in these organs.

Materials and methods.—The parasites were collected with a pen point previously dipped in black India ink on which background the white specimens were easily visible, and with which instrument they were more easily separated from the slimy exudate than would have been possible with a pipette. They were transferred to a watch glass containing physiological saline at room temperature. Specimens to be permanently mounted were fixed with acetic-sublimate, or formalin-alcohol-acetic acid. For staining, Harris's hematoxylin, borax-carmine, and hematoxylin and eosin were employed in various dilutions, and for periods of 10 minutes to 48 hours. When necessary, acid alcohol was used for destaining. Undiluted Harris's hematoxylin applied 10 minutes gave the most satisfactory differentiation.

Diplostomulum sirenis, n. sp.

Description.—General form and anatomy typical. Forebody and hindbody distinct. Forebody in living specimens thin, foliaceous, elongated, slightly concave ventrally, which concavity is retained in many preserved, unmounted specimens. Hindbody short, located posterodorsally on forebody. Oral sucker terminal, mouth ventroterminal. Acetabulum situated anteriorly in posterior half of body, circular in outline in living specimens, transversely elongated in stained mounts as result of longitudinal contraction of entire body.

Hold-fast organ prominent in stained specimens. Lateral suckers short, broad prominences in living and preserved specimens.

Pharynx long, prepharynx short, esophagus longer than prepharynx. Caeca slim, containing, in living, active forms, a dark, granular substance, which is moved slowly backward and forward in the caeca as if by peristaltic waves, and from the presence of which the dilation of the posterior termination of the caeca may be observed.

Fundament of reproductive system a darkly staining, single or irregularly lobulated mass, situated in midline at posteriormost extremity of forebody in preserved specimens.

Urinary bladder occupies greater part of hindbody, with pair of saclike anterior diverticula terminating as separate lobes at a body level immediately posterior to hold-fast organ. In stained sections these appear as isolated vesicles occupying a position between the hold-fast organ and the reproductive fundament. Two or three diverticula also extend laterad from the urinary bladder. Bladders discharge through a short, common duct and dorsoterminal pore, which contracts and relaxes rhythmically. Anteriorly, the urinary bladder proper communicates on either side with the lateral tubular portion of the reserve bladder. The remaining reserve bladder system is essentially the same as described by Hughes (1929). Numerous short

branches of the common collecting trunks, and of their tributaries, end as blind, ellipsoidal vesicles containing, in living and in certain preserved specimens, an ellipsoidal, highly refractile, calcareous concretion. Flame cells appear in pairs.

Living specimens average 0.825 mm extended, without pressure. Measurements on 16 specimens mounted in toto are given in Table 1. The 16 specimens were chosen at random from those subjected to one of each of the different fixatives and stains employed.

TABLE 1.—MEASUREMENTS (IN MILLIMETERS) OF 16 MOUNTED SPECIMENS OF *Diplostomulum sirenis*

Measurement	Minimum	Maximum	Average
Body:			
Length	0.370	0.577	0.482
Width	0.192	0.281	0.243
Oral sucker:			
Length	0.044	0.061	0.051
Width	0.037	0.047	0.042
Pharynx:			
Length	0.024	0.051	0.041
Width	0.013	0.029	0.021
Acetabulum:			
Length	0.034	0.062	0.048
Width	0.047	0.078	0.065
Hold-fast organ:			
Length	0.068	0.119	0.092
Width	0.047	0.081	0.070

Behavior.—In physiological saline, the animals move by attaching the oral sucker to the substrate and contracting the body. The ventral sucker next becomes attached, the oral sucker relaxes, and the anterior portion of the body stretches forward. Progress is slow. When suspended in the liquid, the movements differ in that the posterior portions of the body are alternately flexed on the sides of the body, and extended, without progress forward in space. Light from beneath results in writhing movements.

Host.—*Siren lacertina* (Linnaeus).

Habitat.—Pericardial cavity, in masses attached near ventricle.

Locality.—Marshes of Cumberland River, near Nashville, Tenn.

Type specimen.—U. S. N. M. Helm. Coll. no. 9284, mounted in toto.

Discussion.—The method and duration of fixation and staining have far-reaching effects on the size and appearance of the mounted specimen, especially in the relative size of individual structures. Lateral suckers may, in the same species, be either inverted as cuplike depressions, or extended as protuberances. The acetabulum becomes elongated transversely. The hind-body especially becomes contracted, and the urinary bladder occupies an abnormal position in stained specimens. Therefore, great care should be exercised in the setting up of new species on the basis of minor measurement differentials, the condition of the lateral suckers, or of other superficial characters, in stained mounts. Partially to offset these variations, the measure-

ments in Table 1 were made on specimens subjected to one of each of the several different techniques employed in this study.

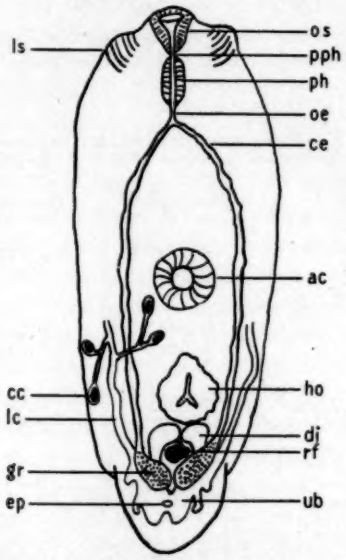

Fig. 1.—*Diplostomulum sirenis*, n.sp.

ac	Acetabulum.	*ls*	Lateral sucker.
cc	Calcareous corpuscle.	*oe*	Esophagus.
ce	Caecum.	*os*	Oral sucker.
di	Bladder diverticulum.	*ph*	Pharynx.
ep	Excretory pore.	*pph*	Prepharynx.
gr	Granular material in caecum.	*rf*	Reproductive fundament.
ho	Hold-fast organ.	*ub*	Urinary bladder.
lc	Lateral collecting vessel.		

D. sirenis resembles five other forms found in North America [*D. browni* Hughes (1929), *D. gigas* Hughes and Berkhout (1929), *D. huronense* (La Rue), described by Hughes and Hall (1929), *D. trituri* Kelley (1934), and *D. ambystomae*, described by Rankin and Hughes (1937)]. *D. sirenis* differs from *D. browni* and *D. huronense* in being larger; from *D. ambystomae* in being consistently smaller in the stained condition, and longer in living specimens, body extended, without pressure. It most nearly approaches *D. gigas* in relative size of structures, stained. *D. sirenis* differs from all these species in the presence of paired, anterior diverticula of the urinary bladder, which lie just posterior to the hold-fast organ. In this respect it resembles *D. trituri* but differs from the latter in relative measurements, which, as pointed out above, should not constitute the sole basis for introducing a new species. The most notable difference in these two forms is the presence of an additional series of conspicuous outpocketings of the reserve bladder in *D. trituri*, re-

sulting in a condition of complexity of this apparatus. Two or three similar outpocketings only are found in *D. sirenis*, and these are confined to the urinary bladder proper. *D. sirenis* is, therefore, intermediate in complexity of the reserve bladder system between *D. gigas*, which is without outpocketings, and *D. trituri*, which has many.

Finally, it is probable that the occurrence of *D. sirenis* in the pericardial cavity of *Siren* is a physiological character of specific importance, since *Triturus viridescens* spends four years strictly on land (Reinke and Chadwick, 1939), while *Siren lacertina* evidently remains, except for short excursions in underground burrows, in water where its food supply exists, and in which medium it may best respire.

Whether the hosts were infected before being placed in captivity is problematical. Three large Sirens, examined several months previously, did not appear to be infected. Opportunities were offered for infection at intervals during the latter two months of captivity, when snails and insect larvae were transferred to the aquarium from marshes where *Siren* are known to exist. Since the latter have not been observed to eat snails, infection may have arisen from one of at least two possible sources: (1) From the insect larvae, by ingestion; (2) from the snails, by swimming of the cercaria in the water, and entrance into the host via the skin (which is very thick), or via the gills or pharynx. Until *D. sirenis* may be isolated from the blood stream it seems logical to assume that the metacercaria found in the pericardial cavity probably are transmitted to the succeeding host when *Siren* is eaten by another vertebrate. Since the latter is often prey to snakes, the final host may therefore be a reptile, although the possibility of *Siren* being devoured by a bird may also exist.

A study of the life history of each of these closely related forms is indicated, to ascertain their exact taxonomic relationships.

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Obituary

WALDEMAR LINDGREN, professor emeritus of geology at the Massachusetts Institute of Technology, died on November 3, 1939. He was born at Kalmar, Sweden, on February 14, 1860. He became interested in geology and mining at an early age and in 1882 was graduated from the Mining Academy at Freiberg, Germany, with the degree of Mining Engineer. In 1884 he began work with the United States Geological Survey, with which he maintained connection for 31 years. In 1905 he was made chief of the Division of Mineral Resources of the Geological Survey, in 1908 was placed in charge of the Section of Metalliferous Deposits, and in 1911 was appointed Chief Geologist of the Survey. In 1912 he was appointed William Barton Rogers Professor of Economic Geology, and head of the Department of Geology, at the Massachusetts Institute of Technology. His book "Mineral Deposits," the first edition of which appeared in 1913, became the leading text and reference on tbis subject throughout the world. Other publications include about 185 titles.

While chairman of the Division of Geology and Geography of the National Research Council (1927–28) Dr. Lindgren established the Annotated Bibliography of Economic Geology, to which he contributed (with a reading knowledge of at least eight languages) about 2,500 abstracts in a 10-year period. He was one of the founders of the Journal of Economic Geology (1905 and served as associate editor.

Dr. Lindgren received many honors in recognition of his achievements. Princeton (1916) and Harvard (1935) conferred honorary degrees, and the Society of Economic Geologists, l'Association des Ingénieurs de Liége, the Geological Society of America, and the Geological Society of London awarded him their medals. The American Institute of Mining and Metallurgical Engineers issued in tribute to him the Lindgren Volume on Ore Deposits of the Western States (1933). He was chosen honorary chairman of the Sixteenth International Geologic Congress held in the United States in 1933.

Dr. Lindgren held membership in the Washington Academy of Sciences, the National Academy of Sciences, the American Philosophical Society, the American Association for the Advancement of Science, the American Institute of Mining and Metallurgical Engineers (honorary life member), the Mining and Metallurgical Society of America (president, 1920), the Geological Society of America (president, 1924), the Society of Economic Geologists (president, 1922), the Geological Society of Washington, and the Geological Society of Boston. He was a foreign member of the Royal Academy of Sciences of Sweden, the Academy of Engineering of Sweden, the Geological Society of London, and the Academy of Sciences of Leningrad. He was a corresponding member of the Canadian Institute of Mining and Metallurgy and the Geological Society of Stockholm and an honorary member of the Geological Society of Belgium.

In 1886 Dr. Lindgren married Ottolina Allstrin of Gothenburg, Sweden, who died in 1929. Lindgren's stimulating and forceful influence on geologic thought is tempered to all who knew him personally by his sympathetic consideration to the viewpoints of others and his kindly and unemotional manner in objections. He possessed an engaging personality and keen sense of humor, and together with his great capacity for accomplishment in his vocation he maintained broad interests in history, art, languages, and world politics.